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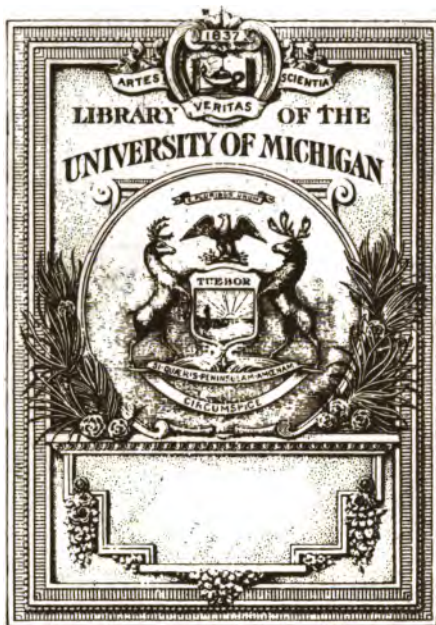
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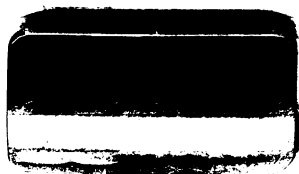
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ANNUAL REPORT
OF THE
COMMISSIONERS OF SHELL
FISHERIES
1918



THE GIFT OF
Commissioners of Shell
Fisheries, Providence, R.I.



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State of Rhode Island and Providence Plantations

ANNUAL REPORT

OF THE

Commissioners of Shell Fisheries

FOR THE

YEAR ENDING DECEMBER 31, 1918

AS MADE TO THE

GENERAL ASSEMBLY

AT ITS

JANUARY SESSION, 1919

PROVIDENCE, R. I.
THE OXFORD PRESS, PRINTERS
1919

Commissioners of Shell Fisheries

AND THEIR DEPUTIES

1919.

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Commissioners of shell fisheries Providence, R. I. Oct. 24, 1919. 3

REPORT

*To the Honorable General Assembly of the State of Rhode Island
and Providence Plantations:*

GENTLEMEN:—In accordance with the provisions of Section 4, of Chapter 203 of the General Laws, the undersigned, Commissioners of Shell Fisheries, beg leave to report to you the condition of this department of the public service, including a detailed statement of all moneys received and expended, on account thereof, also including the names of all the lessees of land, together with the number of acres leased each person, and the rentals received therefor, as of record, for the year ending December 31, 1918.

We are very sorry, to have to report to your Honorable Body, that the Board has sustained the loss of two of its members, by death, during the past year. During the month of October, 1918, the Commission lost two of its members: Col. Randall A. Harrington, October 13th and Hon. William T. Lewis, October 30th. Col. Harrington was Commissioner of Shell Fisheries from Kent County, and Mr. Lewis was Commissioner from Bristol County. While Col. Harrington had not been a member of the Commission but a short time, having been elected to fill the unexpired term of the late John H. Northup, his ability as a business man, together with his earnest effort to render every assistance possible, was of much benefit to the Commission, and his death was a distinct loss to the Commission and to the State.

Hon. William T. Lewis had served as Commissioner of Shell Fisheries from Bristol County from 1900 to 1905, and then again was re-elected January, 1915, this being his second term as Commissioner. Mr. Lewis's experience during his first term enabled him to render valuable services during this term of office. His unflinching courtesy and kindness and his excellent judgment together with his absolute fairness on all matters that come before the Board were of great benefit to the Board and to the State.

In the death of the members just mentioned, the Board has lost two conscientious, careful and considerate members and the State, efficient and valuable servants.

The vacancies caused by the death of the aforementioned members were filled by an appointment of the Governor, as follows: Clinton D. Lewis, December 3, 1918, to fill the vacancy in Bristol County, and Sylvester K. M. Robertson to fill the unexpired term of Col. Harrington from Kent County.

In the consideration of the different matters pertaining to our work, we will consider them by subject and make our recommendations at the close of the discussion of the subject under consideration.

LAWS.

(CHAPTER 203) "Of Private and Several Oyster Fisheries."

Chapter 203 provides for the leasing of ground for the cultivation and propagation of oysters. This chapter was the outgrowth of a series of, what might be termed, experiments that had been conducted for some years under special acts of Legislation, whereby two or three of the citizens of the State had been granted the privilege of planting and growing oysters upon the public ground. After this work had been carried on for several years, it was deemed advisable that there should be a uniform law granting permission to any suitable person, an inhabitant of the State, to take out a lease of ground by paying a fee in the form of rentals, and after the adoption of the constitution of the State in 1842, the chapter pertaining to the leasing of oyster fisheries was enacted.

The conditions that confronted the oyster business in the early fifties were not conducive to the establishment of a very large industry, as there was much opposition to the granting of leases and many of the fishermen believed that the Legislature had granted authority to the Commission that deprived them of obtaining a livelihood from the public domain. They protested vigorously against any leasing of grounds, even going to the extent of taking oysters from leased grounds, in such quantities as to materially retard the progress of the industry. In 1856 this condition became

so serious as to call forth special provisions of the Legislature, in an attempt to remedy the same, and the Commissioners of Shell Fisheries were authorized to take the money obtained from the leasing of oyster ground, and purchase a watch boat to protect the leased areas. The Commissioners of Shell Fisheries did as directed and purchased a boat and attempted to protect the oyster planters, but with very indifferent success, as may be seen from the fact that the industry continued to decrease until in 1864 it was exactly the same as in 1844.

This chapter has been amended from time to time, as circumstances and necessities of the oyster business required. At the January Session of the Legislature in 1917, there was an amendment to this act made by the additions of sections 36 and 37, which provided for the leasing of mud bottom, so-called, for one dollar per year, per acre, to be used for the cultivation of shellfish. This amendment has not proved as advantageous as was expected, and no doubt it could be repealed without materially injuring the oyster business.

It would seem to us, that this chapter could be amended so as to be of much benefit to the State, and particularly if it were amended so the public ground might be rented for other purposes than for oyster cultivation alone. It would seem to us, that it is rather narrow, to lease ground for the cultivation of oysters only, when there are other shellfish that can be raised, upon what is now unused ground, as readily and successfully as oysters. We believe that this act ought to be amended and the Commissioners of Shell Fisheries allowed to lease ground for quahaug and clam culture, as well as for oyster culture, and we would recommend that this chapter be amended so as to give the Commissioners of Shell Fisheries authority to lease ground for shellfish culture.

(CHAPTER 1243) "Of the Protection of Quahaugs."

This is a chapter that was enacted into a law in 1907 and was amended on April 23, 1915.

This chapter prohibits the taking or having in one's possession, quahaugs less than $1\frac{1}{2}$ inches in diameter. Previous to the amendment of this law, there were large quantities of little necks shipped

out of the State, and this practice was so extensive, as to almost destroy the quahaug grounds. Since the enactment of this law, this practice has been stopped, and the little neck industry has increased to a considerable extent. A number of arrests and convictions have been obtained, which has had a salutary effect.

We are of the opinion that this chapter of the law should remain as it is, as it has been an improvement of material benefit to the State.

(CHAPTER 577) "Of the Protection of the Shell Fisheries in the Public Waters of the State."

This is a provision of the law that pertains to the protection of the public health, by providing that no person shall deposit in or allow to escape into the public waters of this State, any substance which shall, in any manner injuriously affect the growth, the sale or flavor of shellfish or shall cause any injury to the public or private fisheries of this State. Under the provisions of this act, the Commissioners are obliged to examine the oyster beds and ascertain if they are free from pollution and if such be the case, to issue certificates granting the use of such beds. This law also provides for the inspection of the opening or shucking houses, and requires that proper sanitary methods should be used in the opening or shucking of oysters and that certificates shall be granted by the Commission, if found to be in proper sanitary condition.

There is one thing relative to this chapter, that may be thoroughly understood, and that is, that just as long as the unsanitary conditions that exist in Rhode Island, are allowed to continue, just so long will the provisions of this chapter have to be carried out in order that the oystermen may be enabled to sell their products in interstate commerce.

We believe that there should be remedial legislation enacted at this term of the Legislature, whereby the pollution of the river and bay will be materially decreased, if not entirely eliminated.

(CHAPTER 852) "An Act Regulating the Taking of Shell Fish from Free and Common Fisheries"

This is a provision that was enacted at the January Session of the General Assembly in 1912 and provides for the granting of li-

censes for the purpose of taking oysters, clams and quahaugs from the public grounds. This act became necessary through the depredations committed by citizens outside of the State, who would come into Rhode Island and take the shellfish and carry them away. There was no way that we were able to prevent the same, until this act was passed.

This act prohibits the use of a dredge upon public ground, excepting in the taking of scollops, as provided by the scollop act; and mussels, which may be allowed by the Commissioners of Shell Fisheries by the issuing of a permit.

(CHAPTER 1602) "An Act for the Planting, Cultivation, Propagation and Developing of any and All Kinds of Shell Fish."

This is an act that was passed by the General Assembly in 1917 and gave the Commissioners of Shell Fisheries authority to conduct any experiment that they might deem best, upon the public ground. Under the provisions of this act, we have closed to the use of the public, certain areas in the bay, in order that the small sets found thereon, could be developed, and it has proved very successful.

In May, 1918, the Commissioners of Shell Fisheries, under authority of this act, closed a piece of ground at New Buttonwoods in East Greenwich Bay and planted 242 bushels of small quahaugs that had been taken from Sand Wharf. This was done in order to ascertain if quahaugs could be transplanted and grown successfully on ground that was barren. This experiment has proven exceedingly successful as it is conservatively estimated to have produced more than one thousand (1,000) bushels from the 242 bushels which were planted thereon. We are contemplating continuing the experiment more extensively, during the coming season, as we believe that we can plant, at least four different pieces of ground with quahaugs, and at the same time and in the same vicinity, plant clams, as we have found that both kinds of shellfish on certain kinds of ground, will flourish and grow rapidly. We hope to be able to do considerable work along these lines during our next season.

A SUMMARY OF THE SHELLFISH LAWS AND RECOMMENDATIONS
PERTAINING THERETO.

First:—We believe that the provisions of the law that allows us to lease ground for the propagation and cultivation of oysters only, is erroneous. We see no good reason why ground should not be leased for oyster, clam and quahaug cultivation and possibly mussel cultivation, as well. We have large areas of public land that is practically worthless, so far as producing revenue to the State and food for the people is concerned, that could be very readily utilized to good advantage, if the law was amended so that we could lease these areas to private enterprise, basing the rental upon a fair and equitable value.

There is no question but what quahaug and clam culture can be conducted as successfully as oyster culture, this has been demonstrated both in Massachusetts and Maine, where ground has been, and is being successfully leased for clam culture.

We believe that if it is the desire of the citizens of the State to have the fisheries fully developed, that the Legislature should give the Commission, authority to lease ground for shellfish culture.

Second:—From our experience in the enforcement of shellfish laws, we are of the opinion that the penalties that are attached to many of our laws are not sufficiently severe to prevent more or less extensive depredations from being committed. It is a great deal more expensive and difficult to apprehend a person that is committing depredations upon the water of Narragansett Bay than it would be to apprehend persons who were committing similar depredations upon the land, and the difficulty in securing convictions, is correspondingly increased. As we have previously stated, we believe that the penalties are not as severe as they ought to be. In fact, we feel that where a person has been apprehended in stealing and carrying away oysters, he ought to be punished by a term in jail, rather than by fining him a small sum, which he is able to pay and almost immediately go out and recuperate himself, by stealing oysters.

We believe that a careful revision of the penalties in the shellfish laws, should be undertaken and that fines and imprisonments be

provided that would be sufficient to materially aid in breaking up the depredations committed in the public waters.

Third:—We believe that there ought to be a co-ordination of the shellfish laws, along the lines of search without warrant. Some of our laws give the Commissioners of Shell Fisheries and their duly authorized agents the right to go upon any boat or vessel where certain kinds of shellfish are unlawfully caught or taken, and search without a warrant, whereas, other provisions of the shellfish law make no mention of any authority for such search, and we believe that the Commissioners of Shell Fisheries should have authority to search for quahaugs or any other shellfish, as well as for scollops. The provision for searching in the unlawful catching of scollops is quite adequate, and we believe that a similar provision should be made for all kinds of shellfish. We would suggest that there be an amendment granting authority to the Commissioners of Shell Fisheries to search, without warrant, any place, other than a dwelling, where in their opinion, shellfish are being caught, taken or held contrary to law.

GROUND EXEMPT BY LAW

Section 13 of Chapter 203, as amended by Chapter 672, provides that no land shall be let north of a line extending across Providence River bearing S 40° 30' W, true meridian, from the copper bolt set in the rock near the end of Kettle Point, to Field's Point, or let any lands west of a line drawn from Warwick Neck Light bearing S 55° 16' 02" W, true meridian, to Pojack Point at Potowomut Neck; or let any land in Sakonnet River south of the railroad bridge, or let any lands in shore of the four-foot line, as delineated on the plats in the office of the Commissioners of Shell Fisheries, or any land lying between a line running due east and west through the middle point of the Rhode Island Yacht Club building, northerly of Pomham beacon, and west of the channel; or let the channel between Long Neck and Marsh Island flats from the channel in the Providence River to the bridge in Pawtuxet; or let any of the ponds in Little Compton, South Kingstown, New Shoreham, Tiverton, Portsmouth, or Westerly, except Brightman's pond or Babcock's Pond, so-called, in said Westerly.

As to the practicability of these exemption lines, there may be considerable question, as some of the areas that are exempt are particularly well fitted for the cultivation of shellfish and the waters of the same, are comparatively clean and especially good for shellfish culture. There is no question but what the exemption line in Providence River should be retained and possibly it might be advisable to extend the line down the river, as this river is becoming unsuitable for shellfish culture or for the production of shellfish of any description, for food purposes.

PUBLIC GROUND

There is no doubt but what the public ground that is available for shellfish culture is being reduced quite rapidly by pollution, but notwithstanding this fact, there are quite large areas in the lower bay which are suitable for some form of shellfish culture, although not suitable for oyster culture. There are some excellent mussel beds in Rhode Island as was reported by Dr. Irving W. Field of the U. S. Bureau of Fisheries and was incorporated in our report to the January Session of the Assembly in 1918. It would seem to us that there might be some use made of these mussel beds that would be of more value than what is being done at this time, as they are not being utilized only for the purpose of supplying fish bait, and the mussel is as nutritious a shellfish as any that we have, and no doubt, if a campaign of education were inaugurated showing the value of mussels, as an article of food, these beds might become valuable food producing areas.

As the oyster industry in Rhode Island is rapidly decreasing, it would seem to us that it would be a wise procedure for other forms of shellfish culture to be undertaken. We feel that encouragement should be given to people who desire to engage in other forms of shellfish culture.

We would recommend that the shellfish laws be amended so as to allow ground to be leased for clam, mussel and quahaug culture as well as for oyster culture.

OYSTER INDUSTRY

We regret very much that we are compelled to call your attention to the fact that the oyster industry of Rhode Island is rapidly decreasing. We have reported this fact, a number of times to your Honorable Body and we feel that unless something is undertaken to relieve the conditions here in Rhode Island, the oyster industry will continue to decrease until we will have very little, or no oyster fisheries remaining.

The leasing of oyster ground in Rhode Island for the propagation and cultivation of oysters has been established for about 120 years. At the beginning, oyster ground was leased by special acts of the General Assembly.

In 1844, the General Assembly created a Commission for that purpose and provided for the leasing of oyster ground for cultivation and propagation. This procedure has been practically continuous ever since. It had grown to a remarkable extent up to the year 1912, at which time conditions became so unsanitary and the areas of leased ground began to be so unproductive that the oystermen were compelled to cancel their holdings. This relinquishment of oyster ground has continued until today, we have less than 50% of the areas under cultivation that we had in 1912. We believe that a further reduction of the areas under cultivation will be made, unless something is done to eliminate the unsanitary conditions of Providence River and the upper bay.

There is no question whatever but what the pollution of Providence River and upper Narragansett Bay is not only destroying the oysters but also the public fisheries as well.

In 1910, when our attention was called to this condition, a conference was held with the U. S. Bureau of Fisheries and Dr. Harvey W. Wiley predicted that unless the State eliminated the source of contamination, in ten years the bay would be so contaminated as to destroy the oyster business. We are obliged to say that Dr. Wiley's prediction is rapidly becoming true. We believe that it is very unwise for the State to allow this condition to exist.

It is not only the fisheries of the State that are being destroyed by this pollution, but the beaches also are becoming worthless for

bathing purposes and the shores adjoining the river and bay as sites for summer residents are becoming greatly depreciated in value, so that this contamination is much broader than the contamination of the fisheries, and if something is not done to eliminate the conditions, we will not only see the loss of the private and public fisheries, but we will also see a great reduction in values of property on the adjoining shores.

If the elimination of this pollution was one of those problems which was unsolvable or that would greatly injure other industries, we might hesitate about attempting to remedy these conditions, but the fact is, that it is comparatively easy to remedy these conditions without any injury to any other business enterprises. Much of the pollution that goes into our bay might readily be taken care of by proper sanitary facilities and the manufacturing wastes that are discharged into our public waters could be taken care of by proper appliances and much of it could be converted into products that would pay a portion, at least, of the expenses of establishing sanitary appliances.

There is no doubt but what, if remedial measures were attempted, there would be extended objections, but we believe that the opposition might be overcome if the proper procedures were adopted, and it was explained that it would not injure other industries to have sewage disposal systems established.

There are a good many acres of oyster ground that have been cancelled during the last five years, as being worthless for the cultivation of oysters, that, ten years ago, were considered very valuable. People from other States were only too anxious to come here and establish business enterprise and secure these areas and plant them with thousands of bushels of oysters. Not only are these private areas destroyed, but a good many acres of public areas where clams and quahaugs may be produced are also very greatly injured and practically destroyed.

We again want to call your attention to these conditions and reiterate that unless some remedial measures be adopted by your Honorable Body at the earliest possible moment.

SANITATION

It became necessary that the sanitary handling and growing of shellfish should be undertaken by your commission, when a number of years ago our attention was called to the condition that existed in Narragansett Bay. In 1910, an act was adopted by the General Assembly of that year, directing the Commissioners of Shell Fisheries to supervise the growing and handling of shellfish.

We have continued this work and have made arrangements with the U. S. Bureau of Chemistry, which enables our oystermen to ship their oysters in interstate commerce. This was brought about by the performing of an extensive examination of our bay and river and by the establishing of sanitary zones. Some of these zones, it has been found, may be utilized for the growing and shipping of shellfish at any and all seasons, while other zones have to be restricted in their use. Some zones are not suitable for the growing of shellfish and very few shellfish are grown in these zones, excepting for the purpose of transplanting.

Under the provisions of sanitation, we have an inspector of oyster houses. It is the duty of the inspector to visit every place where oysters are being opened and to see that the places are kept clean, that proper sanitary methods are used in the opening and packing of oysters, and that there is not an undue length of time used in the washing and cooling of the oysters.

The inspector reports the conditions to the Office of the Commission, upon cards prepared for that purpose, and certificates are granted to the owner of the opening houses in accordance with his report. Also in connection with the work of the inspector, we are furnished with information relative to the quantity of oysters opened and shipped per day and the number of employees engaged in the industry. In accordance with the report of the inspector, the average number of openers during the month of December, 1918, was 214 and the average number of gallons of oysters opened and shipped per day was, 3240, and the number of houses doing business in Rhode Island at that time was 19.

While the work that is being undertaken under the provisions of our laws enables the oystermen to furnish a wholesome and sani-

tary article of food, and to ship the same in interstate commerce, it does not assist the oystermen in endeavoring to discover and eliminate some of the conditions that are very injurious to the growth of oysters.

The sanitary work during the past year has been performed for us by the State Board of Health, and we are in hopes to continue the arrangement with the Board of Health. We can assure you, that as long as conditions exist in Rhode Island, as they are now, it will be necessary for sanitary supervision to be observed.

REPORT OF CHEMIST AND SANITARY ENGINEER OF THE STATE BOARD OF HEALTH

Commissioners of Shell Fisheries:

GENTLEMEN:—I present herewith a report of the various sanitary investigations performed for you during the past year by the staff of the State Board of Health.

The work during the year, in addition to the usual examinations of samples of oysters and investigations necessary for the sanitary control of leased oyster beds, has included a study of the sanitary condition of clams and quahaugs on certain of the unleased ground, and a study of the pollution of the waters of upper Narragansett Bay. In addition, some investigations were made of the unusual mortality among soft clams on certain areas and a number of samples of the wastes discharged from certain industrial establishments located on the Providence and Seekonk Rivers were collected and examined.

SANITARY CERTIFICATES

Following the procedure adopted in 1916, the leased oyster grounds in the State have been divided into two general classes: In one class are included all grounds which examinations during previous years had shown to be in safe sanitary condition throughout the oyster season and for which sanitary certificates could safely be granted without the necessity of making analytical tests for freedom from pollution. This class comprises the leased beds on the west side of the bay south of Rocky Point, the beds around Prudence and Conanicut Islands, and the beds in the southerly part of the Sakonnet River.

In the other class are included those areas which previous investigations have shown are usually in safe sanitary condition during cold weather, but which we must depend on bacterial tests to de-

termine how early in the season oysters taken from them, may safely be permitted to be marketed. For convenience in sampling and control work these doubtful grounds have been grouped into six sub-zones or areas with natural geographical boundaries, and in making examinations of such areas the sampling points have been so located that a representative idea of the sanitary condition of the entire area may be obtained. Under this procedure all the oyster beds in one geographical group are treated as a unit, and sanitary certificates are issued to all leasees as soon as the oysters on that area are found to be of proper quality. Owners of oyster grounds in a given territory are thus placed on a uniform basis and are permitted to open up their grounds at the same time if they wish.

The six sub-zones covering the doubtful areas are as follows: LONGMEADOW—including all beds on the west side of the bay between Rocky Point and Conimicut Point; NAYATT—including the various beds on the southerly side of Nayatt Point; WARREN—including the beds in the Warren River and those on the east side of the bay lying between the northerly part of Poppasquash Neck and Rumstick Point; BRISTOL—including all beds in Bristol Harbor and those around Hog Island; KICKEMUIT—including the beds in the Kickemuit River and those located immediately south in Sections 44, 61 and 66 on the map of leased oyster grounds; PORTSMOUTH—including the various beds in the northerly part of the Sakonnet River and those beds located north of the Island of Rhode Island in sections 95, 96, 114 on the map.

Examinations were made of the Nayatt area on August 28th, Sept. 28, and October 15. This area was found to be clear on the latter date and certificates were issued on Oct. 19. The Longmeadow area was examined on Aug. 28, Sept. 3 and Sept. 28, and certificates were granted on Oct. 1. The Portsmouth area was examined on Sept. 5, Oct. 8, and Nov. 8, and the Kickemuit area on Oct. 8 and Nov. 8, and certificates for both these areas were granted on Nov. 13. The Warren River area was examined on Sept. 10, Oct. 19 and Nov. 16. On the latter date Bed No. 28-J and those beds lying south of it were found to be clear, but as beds lying farther up the river still showed contamination from the sewage discharged from the town of Warren, it was deemed advisable

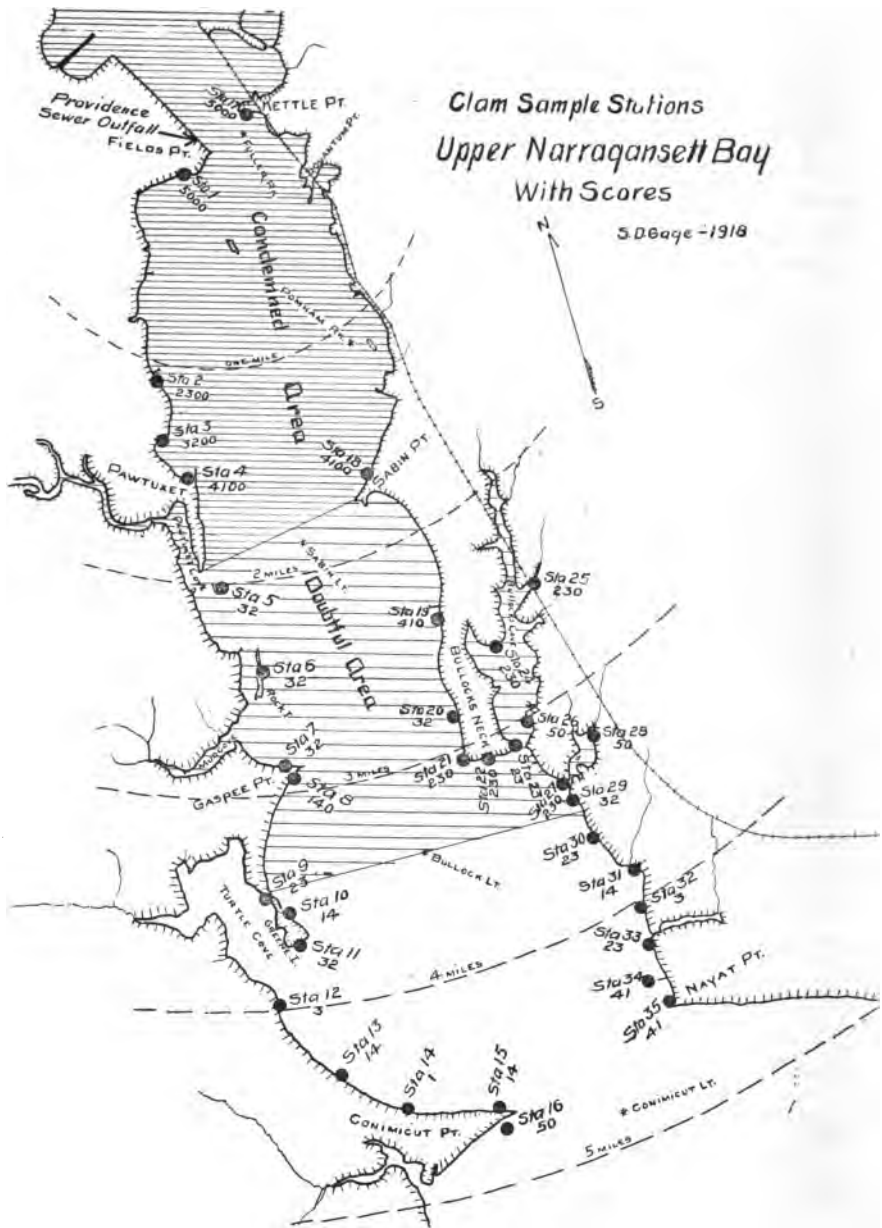
to subdivide the area and certificates were granted for the southerly part on Nov. 19. The Bristol area was examined on Oct. 2 and Nov. 2. Sanitary certificates were granted for all but one of the beds in this area on Nov. 7, but as this bed was located in close proximity to two of the large town sewers, it was not considered safe to permit the oysters from it to be used for food although the bacterial scores were within the prescribed limit.

SANITARY CONDITION OF CLAMS AND QUahaUGS

Early in the summer you authorized me to investigate the sanitary condition of clams and quahaugs from different areas and also to make some studies of the pollution of the waters of the bay. Owing to war conditions, considerable difficulty was experienced in obtaining suitable assistance to carry out these investigations and active work along these lines could not be started until the second week in July. The clam investigation was also slowed up materially by the fact that we had to use the motor boat "Pearl" which was of too great draft for such work, and much time was lost in rowing to and from shore at each sampling point. Clam samples necessarily have to be taken at low water and more ground could have been covered at each sampling trip if we had had a light draft power skiff with which we could have run directly from one sampling point to another without waste of time. In order to make the most of the time available, therefore, this part of the investigation was largely confined to clam areas in the upper bay, with a few samples only from points in Greenwich Bay and the Warren River. In the main, also the investigation was confined to soft clams, although a few samples of quahaugs were examined.

The results of this investigation show that clams from points in the upper bay, north of a line drawn from the Pawtuxet Yacht Club to Sabine's Point are very badly polluted.

On the west shore south of Pawtuxet Cove, scores were generally within the limit upon which sanitary certificates are granted for oysters, although high scores were found at one point on the south side of Gaspee Point.



On the east side of the bay, clams or quahaugs showing scores considerably above the prescribed limit were found at Crescent Park, on the southerly side of Bullock's Neck, in Bullock's Cove and in the small inlet south of Bullock's Cove.

As a result of this investigation it is possible to divide the shellfish ground of the upper bay into three zones of varying pollution. It is evident that the clam and quahaug grounds north of a line drawn from Pawtuxet Cove to Sabine's Point, the dark shaded area on the map, are so seriously polluted that shellfish taken from them are absolutely unfit for food. The taking or sale of shellfish for food from this area should be prohibited. Between the southerly limit of this zone and a line drawn east and west through Bullock's Light, the light shaded area on the map, is an area which is less seriously polluted. Clams and quahaugs from this area are undoubtedly dirty, but if thoroughly cooked, might not be dangerous. South of the Bullock's Light Line all scores were within the limit prescribed for oysters, although it is probable that under different conditions of wind and tide, higher scores might have been obtained. Shellfish from this area are certainly not of the highest standard of cleanliness, although when cooked, they might safely be used as food.

The results of examination of clams and quahaugs are shown in the following table, and the location of sampling stations in the upper bay together with the sanitary score at each station are shown on the accompanying chart.

SANITARY SCORES OF CLAMS AND QUAHAUGS

Station No.	LOCATION.	Date.	Score.
WEST SHORE—UPPER BAY.			
1	Below Field's Point	Aug. 8	5000
2	100 yard south of Edgewood Yacht Club.....	Aug. 8	2300
3	North end of Stillhouse Cove.....	Aug. 8	3200
4	Stillhouse Cove, near R. Yacht Club.....	Aug. 8	4100
5	Marsh Island, mouth of Pawtuxet Cove.....	July 16	32
6	East shore Rock Island (Quahaugs).....	Aug. 28	32
7	North side Gaspee Point		
8	South side Gaspee Point	July 19	140

of the sewage to absorb oxygen and the capacity of the water to supply that oxygen. If the oxygen capacity of the water is high, a much larger volume of sewage may be disposed of in this way than if the water is of low oxygen content.

It is estimated that the volume of water passing Field's Point due to the ebb and flow of the tides is about 5460 million gallons every twenty-four hours, or something over 200 times the daily volume of sewage discharged. Studies in the laboratories of the State Board of Health during the past few years show that approximately 1100 volumes of water of sea water of the average quality of that at Field's Point would be necessary to supply the oxygen required by each volume of sewage discharged. It is evident therefore, that even if the sewage were evenly distributed through the water, so as to utilize the full effect of the dilution, the margin of safety is none too large to prevent the waters of the upper bay from becoming a nuisance.

Another effect of the admixture of sewage with salt water is to cause a precipitation of the suspended and colloidal matters of the sewage, and unless the current of water flowing is sufficient to carry them away, these depositive matters are likely to collect on the bottom and form sludge beds of highly putrescible character which require large amounts of oxygen for their eventual decomposition. Deposits of this nature were particularly in evidence at our sampling stations numbered 1, 2, 3, and 4.

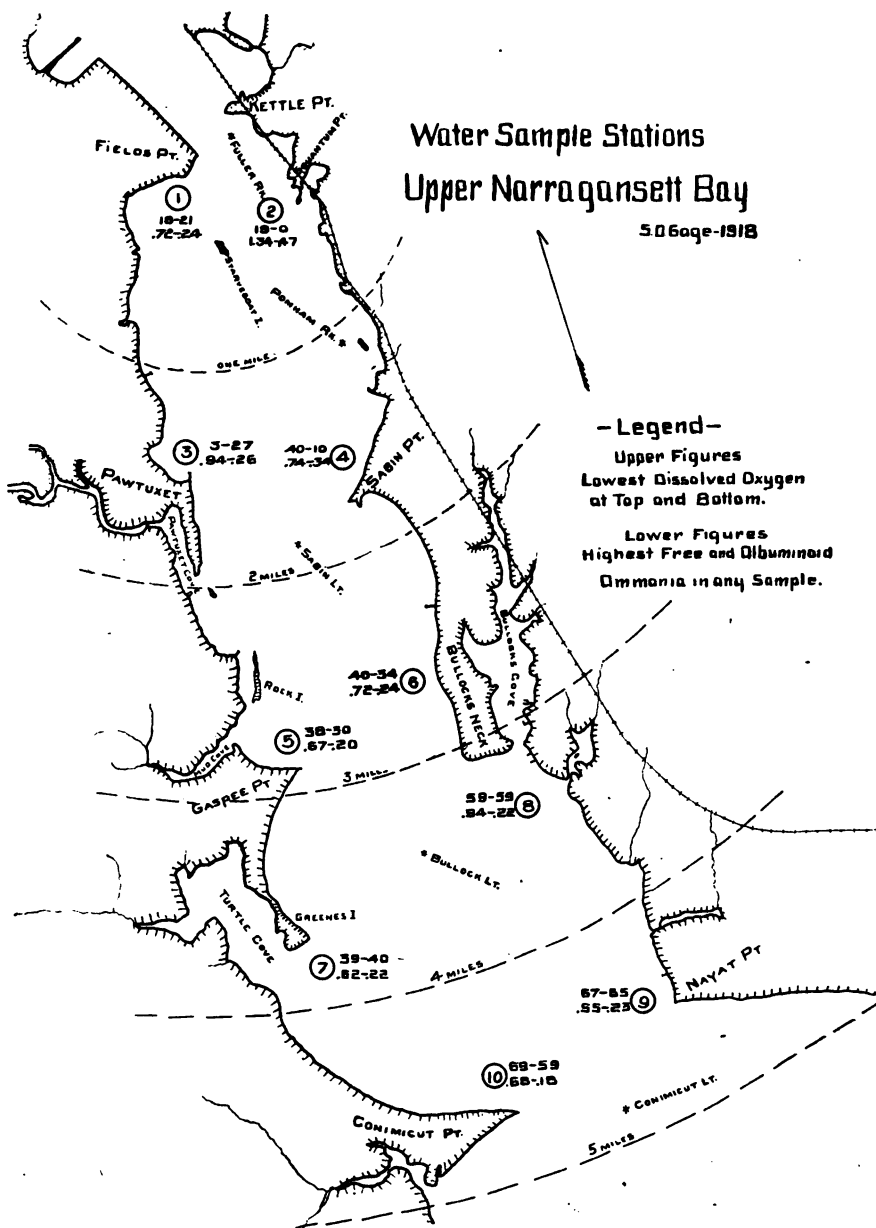
The present pollution of the upper part of Narragansett Bay, however, must not be attributed entirely to the discharge of the Providence sewage at Field's Point. Pawtucket, Central Falls and East Providence, all contribute to this pollution through the discharge of sewage and manufacturing wastes into the Blackstone, Seekonk and Moshassuck Rivers. The shape of the upper end of the bay also has considerable influence upon the degree of pollution. Topographically the Providence River and upper bay down to Conimicut and Nayatt Points are not unlike the neck of a tunnel of which the lower bay forms the bell. If all of the water entering between Conimicut and Nayatt Points with the incoming tides could be discharged into the upper part of the Providence River, the dilution would probably be ample to care for all of the sewage now

being discharged into that river. The incoming and outgoing tides, however, tend to produce a shuttle effect with the result that all of the sewage entering at Field's Point, and all the polluted waters coming down the Providence River do not pass out into the lower bay with the ebb tide but are in part driven back by the incoming tide thereby increasing the pollution of the water and diminishing its capacity to absorb more sewage.

Practical studies of pollution in New York Harbor and elsewhere have shown that it is unsafe to permit the dissolved oxygen content of the water in the summer time to be reduced below about fifty per cent. of that required for saturation. On August 11, when the poorest conditions were found, the water collected from both top and bottom at seven of our sampling stations contained less than this amount of oxygen. On July 29, oxygen values below the safe limit were found in bottom samples collected from Stations 2, 4, 5, and 6, and on August 26, the oxygen was below the safe limit at both top and bottom at stations 1, 2, 3, and 4, and at the bottom at stations 5 and 6.

It is evident from these results that during the past summer the pollution in the greater portion of that part of the bay lying between Field's Point and Conimicut exceeded the safe limit at times. In fact, on August 12, water from the bottom at station 2 was entirely devoid of oxygen and that from the bottom at station 4 contained only about 10% of the amount of oxygen required for saturation. While we may not know definitely how much or how little oxygen is necessary to support shellfish life, it is certain that shellfish could not live at station 2 under these conditions and it is probable that they could not live at station 4.

The oxygen content of the water at top and bottom at each of these stations on different dates is shown in the following table and the lowest oxygen found at each station is plotted on an accompanying chart.



DISSOLVED OXYGEN CONTENT OF WATER IN UPPER BAY.

Station.	Depth of Water—Feet.			Dissolved Oxygen—Per Cent. Saturation.					
	July 29.	Aug. 12.	Aug. 26.	July 29.		Aug. 12.		Aug. 26.	
				Top.	Bottom.	Top.	Bottom.	Top.	Bottom.
1.....	10	6	12	65	61	18	21	33	31
2.....	18	21	15	53	51	19	0	34	32
3.....	10	7	9	66	54	3	27	50	48
4.....	15	10	12	86	42	40	10	37	43
5.....	11	10	8	68	49	38	30	75	50
6.....	9	12	9	62	40	40	34	72	49
7.....	6	9	5	87	72	39	40	100	100
8.....	10	9	9	82	76	59	59	58	51
9.....	12	9	6	100	99	69	59	98	91
10.....	9	14	12	81	73	67	65	100	96

Average Temperature of Water July 29—Top, 76°F. Bottom, 76°F.

Aug. 12—Top, 73°F. Bottom, 71°F.

Aug. 29—Top, 77°F. Bottom, 76°F.

Determinations of free and albuminoid ammonia in samples from nearly all of these various stations also show excessive pollution at times. The numbers of bacteria and *B. coli* were much lower than we would normally expect to find in waters showing such a high degree of pollution by chemical analysis. This is explained, however, when we take into consideration that the larger part of this pollution is due to Providence sewage and that this sewage is disinfected before being discharged.

The results of the various chemical and bacterial analyses of samples from these stations are shown in following tables, and the location of the different stations together with the worst conditions found at each one are plotted on the accompanying chart.

CHEMICAL ANALYSES OF WATER FROM UPPER BAY.

(Parts per million.)									
Station.	Time	Chlorine.		Free Ammonia.		Albuminoid Ammonia.		Nitrites.	
		Top.	Bottom.	Top.	Bottom.	Top.	Bottom.	Top.	Bottom.
July 29, 1918—Stiff S. E. wind; high tide at 1:20 p. m.									
1	12:30	12500	13200	.61	.62	.24	.19	.000	.000
2	12:40	12600	13600	.13	.66	..	.27	.016	.000
3	1:15	13200	13300	.42	.38	.24	.18	.012	.006
4	1:10	13500	14600	.49	.72	.29	.34	.013	.012
5	11:45	14400	13500	.48	..	.18	..	.000	...
6	9:00	12600	13400	.60	.60	.24	.23	.018	.016
7	11:20	14800	14500	.19	..	.21	.22	.016	.007
8	9:30	14000	14100	.50	.32	.22	.18	.018	.016
9	10:40	14500	14600	.09	..	.11	.18	.000	.000
10	10:05	14000	15200	.43	.23	.18	.23	.010	.008
August 12, 1918—No wind; high tide at 10:45 a. m.									
1	9:50	13500	13800	.72	.68	.18	.16	.028	.025
2	10:00	13500	15500	.75	.67	.20	.41	.030	.020
3	9:40	13700	16200	.94	.63	.24	..	.020	.015
4	10:30	14100	15100	.74	.67	.21	.21	.020	.015
5	11:55	13700	15700	.67	.61	.09	.07	.020	.020
6	10:45	12500	15400	.72	.46	.16	.10	.020	.015
7	11:40	14400	15300	.19	.62	.13	.12	.020	.020
8	11:00	14400	15800	.73	.94	.13	.12	.025	.020
9	11:25	14800	15900	.69	.48	.18	.11	.020	.015
August 29, 1918—Stiff S. W. wind; high tide at noon.									
10	11:15	14900	16600	.55	.42	.22	.09	.020	.015
1	1:30	13200	13300	.70	.48	.20	.22	.000	.000
2	1:45	12500	13800	1.34	.61	.47	.19	.000	.003
3	2:15	13900	13000	.68	.49	.26	.21	.004	.004
4	2:00	13800	14600	.60	.41	.21	.15	.005	.003
5	2:45	13800	15000	.43	.32	.20	.13	.004	.001
6	2:30	15000	13500	.32	.31	.19	.15	.003	.002
7	3:30	15000	14700	.02	.06	.21	.21	.001	.001
8	3:15	147000	14200	.27	.24	.14	.14	.002	.002
9	4:00	15600	15000	.09	.02	.20	.16	.000	.001
10	3:45	15500	15500	.14	.09	.19	.15	.001	.001

RESULTS OF BACTERIAL ANALYSIS OF WATER FROM UPPER BAY.

Station.	Total Bacteria 37° C.		B. Coll Found in	
	Top.	Bottom.	Top.	Bottom.
July 29, 1918.				
1	2200	300	.01 c.c.	.01 c.c.
2	3100	5100	.001	.01
3	1400	1000	.1	1.0
4	1300	1600	1.0	0.1
5	2400	300	.1	1.0
6	1200	4500	.1	.1
7	300	600	1.0	1.0
8	600	700	1.0	1.0
9	1500	2200	.0	.0
10	2800	800	.1	.1
August 12, 1918.				
1	2900	9100	.01	.01
2	2600	1600	.01	.01
3	5100	2500	.1	.01
4	2700	2500	.1	.1
5	2900	1900	.1	.1
6	2500	2400	.1	.1
7	800	4900	1.0	.01
8	5200	3400	0.1	0.1
9	2900	5900	1.0	.1
10	1100	2500	.1	.1
August 26, 1918.				
1	3600	2800	.001	.001
2		5300	....	.001
3	750	575	.1	.01
4	1250	600	.01	.1
5	2300	425	.1	.1
6	1750	200	.1	1.0
7	5600	150	1.0	.0
8	250	125	.0	1.0
9	950	350	.0	.0
10	1000	450	.0	.0

EFFECT OF SEWAGE AND MANUFACTURING WASTES ON SHELLFISH

As the decline of the oyster and other shellfish industries in the State during the past few years has been attributed to the growing

pollution of the waters in which these shellfish are grown, it may not be out of place to discuss the possible effect of pollution on fish life. In considering cause and effect we must divide this pollution into three general classes: that caused by city or household sewage; that caused by those waste liquors from manufacturing or industrial processes which mix intimately with water; and that caused by such industrial wastes as tar, oil, etc., which do not mix with the water.

City sewage may injuriously affect the shellfish industry in two ways. Through contamination with city sewage, shellfish may become unfit for food either by reason of their filthy condition or because they may carry disease producing bacteria. Typhoid fever has been known to be caused by infected oysters and for this reason no oysters are permitted to be taken from leased areas in Rhode Island until they have been proved by bacteriological examination to be free from dangerous pollution. Infection of this kind can be controlled by thorough purification of the sewage or by treatment of that sewage with some chemical which will destroy all disease germs. The sewage from the city of Providence discharged at Field's Point is treated with disinfectant for this reason. Another, and perhaps not less serious effect of excessive pollution by city sewage may be caused by the fact that a large amount of oxygen is needed to oxidize the sewage after it has been diluted with sea water. If the volume of sewage discharged into any body of water is excessive, the amount of oxygen in the water may be reduced to a point where the shellfish cannot obtain from the water the oxygen necessary to enable them to live and propagate.

Manufacturing wastes from certain industries also require large amounts of oxygen for their decomposition, and excessive pollution with such wastes may also reduce the oxygen content of the water below the point necessary to sustain fish life. Other kinds of manufacturing wastes may contain acids, dyes, or other chemicals which in any considerable concentration may either directly kill the shellfish or prevent their propagation, or what is equally serious, may destroy the diatoms and other small living organisms upon which these shellfish must depend for food.

The oils and tars being usually lighter than the water, float upon the surface and are thus less likely to affect the adult oysters and

quahaugs which live in deep water. The floating oil or tar may, however, become so loaded with dust, that it sinks to the bottom and under such conditions the flavor of these deep water shellfish will be impaired even although their life may not be interfered with. The soft clam, growing as it does in the sand and mud above low water line, is very likely to be injured by the oil or tar thrown upon the flats by wind and wave action. In a number of places in Narragansett Bay the clams are so highly flavored with oil or tar that they are unfit for food. It is believed that oil and tar may also destroy the set of oysters. The oyster eggs hatch into small free swimming organisms or spat, which for a short time live at the surface of the water. If the water is covered with a film of oil or tar at this time the spat may be killed, and the set of young oysters either prevented or greatly reduced.

We have yet much to learn about the effect of sewage, manufacturing wastes and oils upon shellfish. Many of the previous statements are based on studies of the life history of other kinds of fish, and while probably true, have not yet been proved in the case of shellfish. We do not know definitely how much or how little oxygen in the water is required to support life in the growing oyster or clam. We do not know just what effect the various chemicals which are found in different manufacturing wastes may have on adult shellfish or upon the eggs and spat of shellfish. We also do not know nearly as much as we should about the effect of these various polluting materials on the small organisms which form the food supply of oysters, clams, etc., although we do know that when the pollution is not too great, the supply of microscopic shellfish food is usually greater in water contaminated with sewage than it is in very pure waters. A large amount of constructive experimental work is necessary in order that we may know definitely what limits of pollution should be established for our various shellfish bearing waters.

Another effect of pollution which may affect shellfish life is that due to the stimulation of excessive growths of *Ulva*, sea-lettuce, or sea-cabbage, as it is variously called. This variety of sea-weed, which is seldom found in clean waters, grows prolifically in waters in which the oxygen content has been reduced by sewage pollution

and so dense is this growth at times that clams and other growing shellfish are effectually destroyed. When it dies, or when broken off by the action of winds or tides ulva decays rapidly, not only producing an offensive nuisance, but robbing the water still further of its oxygen content. In August, 1918, for a number of days, all parts of the bay were filled with floating masses of sea-cabbage in process of decomposition. Within the past five years, extensive growths of ulva have developed in the upper bay and a number of formerly productive clam growing grounds have been entirely destroyed.

THE FREE SHELL FISHERIES

The productiveness of the oyster industry in Rhode Island being quite largely confined to leased ground under direct State control, is a known quantity, and as this industry returns a considerable income in rentals and taxes, its importance as an asset to the State has been well recognized and measures have been taken from time to time for its further development. Comparatively little attention has been paid, however, to the uncontrolled grounds which are free to the public and little is known about their value or productiveness. A conservative estimate shows that there are between 15,000 and 20,000 acres of uncontrolled ground in Narragansett Bay which are producing food in the form of clams, quahaugs, oysters and mussels and scallops or about twice the area of the leased oyster beds in 1918.

With the assistance of your various deputies, estimates have been made of the catch of these varieties of shellfish in different parts of the State during 1918. From these estimates it is evident that the total yield of these unleased areas was something like 78,000 bushels of clams, quahaugs and oysters, and 3500 gallons of scallops, and that the market value of this crop was almost \$200,000. The estimated yield and value of the different varieties of shellfish from open territory is as follows:

	Quantity	Market Value
Clams	40,000 bushels.....	\$70,000
Quahaugs	25,000 "	100,000
Mussels	8,000 "	4,000
Oysters	5,000 "	5,500
Scollops	3,500 gallons.....	14,000
Total		<u>\$193,000</u>

In any discussion of the value of the shellfisheries to the State as a whole, we should consider the amount of food produced rather than the market value of the product or direct income to the State in the form of rents and taxes. The food value of a gallon of oyster meats and the same amount of clams, quahaugs or mussels is practically the same, although the market value of the oysters and quahaugs is considerably greater than that of the clams or mussels. On the basis of food value, the productiveness of the free fisheries in clams and mussels alone was nearly two and one half times as great as the productiveness of the leased oyster beds during 1918, and the total food value of the shellfish catch from the uncontrolled and uncared for areas was nearly five times that from the controlled oyster bearing areas.

There is no question that with proper care and supervision the productiveness of the land under the waters of Narragansett Bay could be increased enormously. If it is a wise policy for the State to assist in every possible way in developing and increasing the productiveness of our farms on land, why should not this same policy be extended to our under-water farms?

In considering the food value of shellfish products special mention should be made of mussels. There are large beds of mussels in the State which are not worked or are not productive because there is little sale for this kind of shellfish. On the market today mussels are valued at only fifty cents per bushel, thus being the cheapest of all shellfish food. When properly prepared mussels are fully as good food as clams, quahaugs, or oysters, and at a time like the present when prices of other foods are unreasonably high, it would seem that every effort should be made to educate the people to utilize to its fullest extent this valuable source of low-priced food.

In my report for 1917, I recommended that the sanitary control

which for a number of years has been exercised over leased oyster grounds be extended to all free grounds and be made to cover clams and quahaugs as well as oysters. The greatest consumption of clams and quahaugs is during the off season for oysters, when according to all available evidence, sanitary conditions are at their worst. Soft clams, although used in large quantities during the summer, are usually cooked before being eaten and the danger of transmission of disease through their means is thereby largely reduced. A few people eat soft clams from the shell without cooking, however, and little necks or the smaller quahaugs are eaten raw in large quantities. From a health viewpoint, therefore, sanitary control is as essential for clams and quahaugs as it is for oysters, and we certainly should not permit polluted oysters to be marketed from free ground any more than we do from leased ground. Furthermore, it would seem that common decency and cleanliness require that the innocent consumer be safeguarded against the sale of clams and other shellfish which are filthy with sewage, even though we may have every reason to believe that these shellfish would not be dangerous if they were properly cooked.

Respectfully submitted,

STEPHEN DEM. GAGE,
Chemist and Sanitary Engineer.

METROPOLITAN SEWAGE COMMISSION.

In our report of 1918, we very strongly recommended that there be established a Metropolitan Sewage Commission and there was an act introduced creating such a commission, but it was never reported. We are still of the opinion that ultimately it will be found that such a board should be established and that the State, together with the cities and towns, should assume the cost of establishing and maintaining such a commission, but that the supervision of the sewage system should be wholly in the hands of the State. A measure of this kind has been before your Honorable Assembly for a number of years, but it does not seem to meet with very much encouragement. We feel that the longer this matter is continued, the greater will be the cost of establishing such a system and it would seem to us that the sooner such a commission was established and work begun, the easier and better it would be for all parties interested. We recommend that this matter be given thorough consideration.

MEETING OF THE NATIONAL ASSOCIATION OF FISHERIES COMMISSIONERS.

The Tenth Annual Convention was held at Richmond, Virginia, on May 14th and 15th, 1918, at the Hotel Murphy. Rhode Island was represented by Commissioner of Shell Fisheries, Milton Duckworth, and Clerk of the Board, Brayton A. Round.

The convention was called to order by W. McDonald Lee, former President of the Association, who welcomed the convention to Virginia and presented Hon. George Ainslie, Mayor of Richmond. He delivered a very cordial and warm welcome. A response was delivered by Dr. William R. Thompson.

In the afternoon session, the President, Brayton A. Round, delivered the annual address, which was followed by a paper by Dr. E. P. Churchill, Bureau of Fisheries, Washington, D. C. At the close of the presentation of the paper, by Dr. Churchill, John W. Titcomb, Fish Culturist to the Conservation Commission, New York, delivered an address which was followed by general discussion of the preceding paper. After the general discussion, Hon.

H. L. Gibbs of North Carolina presented a paper on "Conservation and Co-operation."

On May 15th, the morning session was opened with a paper by Dr. Irving A. Field, Clark College, Worcester, Mass., on "The Food of the Oyster," which was followed by a discussion, after which a paper was presented on the "Bacteriology of the Oyster" by Lester A. Round, Ph. D., Bureau of Chemistry, in which a review was given of the transmission of disease, cleansing of oysters, hibernation, conditions necessary for proper handling and shipping. This was followed by an address on "Contamination of our Fisheries and Methods to Prevent the Same" by W. Thomas Kemp, Chairman of the Conservation Commission of Maryland. This was followed by a general discussion of the subject, in which the general pollution of State Waters were given much consideration.

The afternoon session of May 15th was opened with a paper by George A. Mott on "How New Jersey Oyster Beds were depleted under the old System of Depending on Nature to furnish a supply and how the same has been developed by Applying Business Principles." At the close of Mr. Mott's paper, a general discussion was made, after which the members of the Association were taken down York River, in the City Launch, Thomas Cunningham. This boat was tendered the Association by the Administrative Board of the Chamber of Commerce.

OYSTERS.

Oysters are the only shellfish cultivated by private enterprises in Rhode Island, although there is no reason why other shellfish should not be cultivated as successfully as oysters. In fact, we feel that quahaugs and clams could be cultivated probably more successfully than oysters, as the enemies to the oysters are much more abundant than to the other shellfish. No doubt if there was some way in which the general proposition of shellfish cultivation could be undertaken, there would be as many engaged in the cultivation of clams, quahaugs and mussels as there are in the cultivation of oysters. While oyster cultivation has been practiced for hundreds and, in fact, thousands of years, other shellfish cultivation

has only recently been taken up and then in other states than Rhode Island. Massachusetts and Maine have enacted laws that allow the cultivation of quahaugs and clams by private enterprises.

The estimated number of oysters taken from public ground during 1918, is about 5,000 bushels, and the average price per bushel is about \$1.10, making a total of \$5,500.

There has been a lack of oyster sets in Rhode Island for the last four or five years. This condition has been very injurious to the growth of the oyster industry, as the oystermen have used up all of their surplus stock, in fact, we have been informed that many of the oystermen are almost without oysters for the ensuing year. This lack of set has occurred not only in Rhode Island, but also in Connecticut. In years past, when the oystermen of Rhode Island were unable to obtain young oysters here, they could readily go to Connecticut and purchase the same, and transplant them profitably, whereas, at this time, there are no young oysters available either in Rhode Island or Connecticut.

This condition has become so acute, that we have taken the matter up with the U. S. Bureau of Fisheries, trying to ascertain why oyster sets are not as prevalent here, as formerly. The U. S. Bureau of Fisheries directed Dr. Mitchell to conduct a series of experiments during the last season, which has been done, and the reports of Dr. Mitchell, and of Dr. Albert C. Hunter of the U. S. Bureau of Chemistry follow:

A REPORT CONCERNING THE FAILURE OF OYSTERS TO PROPAGATE IN NARRAGANSETT BAY.

PHILIP H. MITCHELL.

The work here reported was undertaken with two projects in view: (1) to observe the general conditions of oyster propagation in Narragansett Bay, the spawn of oysters on the beds, the time of emitting the spawn, the presence and distribution of "set" at the end of the season; (2) to attempt artificial propagation of oysters by a modification of the method used in lobster hatching at the Wickford Plant of the Rhode Island Inland Fish Commission.

The results may be briefly summarized as follows: natural propagation of oysters did not occur in the greater part of Narragansett Bay. This is in accord with reports for the past ten years. Spawn found in oysters during the early part of the summer on five beds in localities representative of the main part of Narragansett Bay was sufficiently abundant to indicate nothing unusual in nutritive condition and apparent reproductive power of the oysters. Water samples taken from stations widely dispersed in the main part of the Bay did not show oyster fry until after the first of August, and those few in number. Only small numbers, mostly in early embryonic stages were found during the month following their first appearance. Corresponding to observations on water samples the findings of oyster "sets" observed in September were in the main part of the Bay few in number, restricted in location, and so small as to indicate that they formed late in the season, probably about September 1.

In a few restricted localities which might be regarded as inlets a more noticeable "set" occurred. At the head of Narragansett Bay, in the Providence River, there was a very fair set which in September had attained a size indicating that it had formed early in the summer. In Wickford Harbor on the floats of the lobster hatchery oysters "set" about August 1, and although this was not sufficiently large to be of any practical value the young oysters were thick in some spots. A "set" reported to be of value formed

in an inlet into which the Narrow River empties near the southern end of Narragansett Bay. The first of these three "sets" found in the region of the Providence River is reported by an agent of the R. I. State Commission of Shell Fisheries to have partly died before November 1. Whether or not this was caused by pollution cannot be said, but seems possible. It may, therefore, be concluded that there was practically no successful reproduction of oysters in the bay during the season of 1918. Observations indicate that this was typical of recent years. Shells only a few millimeters in length indicating a light and late "set" formed in 1917, but not surviving the winter, were found in many localities, while in the Providence River and in Wickford Harbor plentiful specimens of year-old oysters were found, but many empty shells of the same size occurred in the Providence River. The second project undertaken gave a negative result. A modification of the method used in hatching lobsters was entirely unsuccessful applied to oysters.

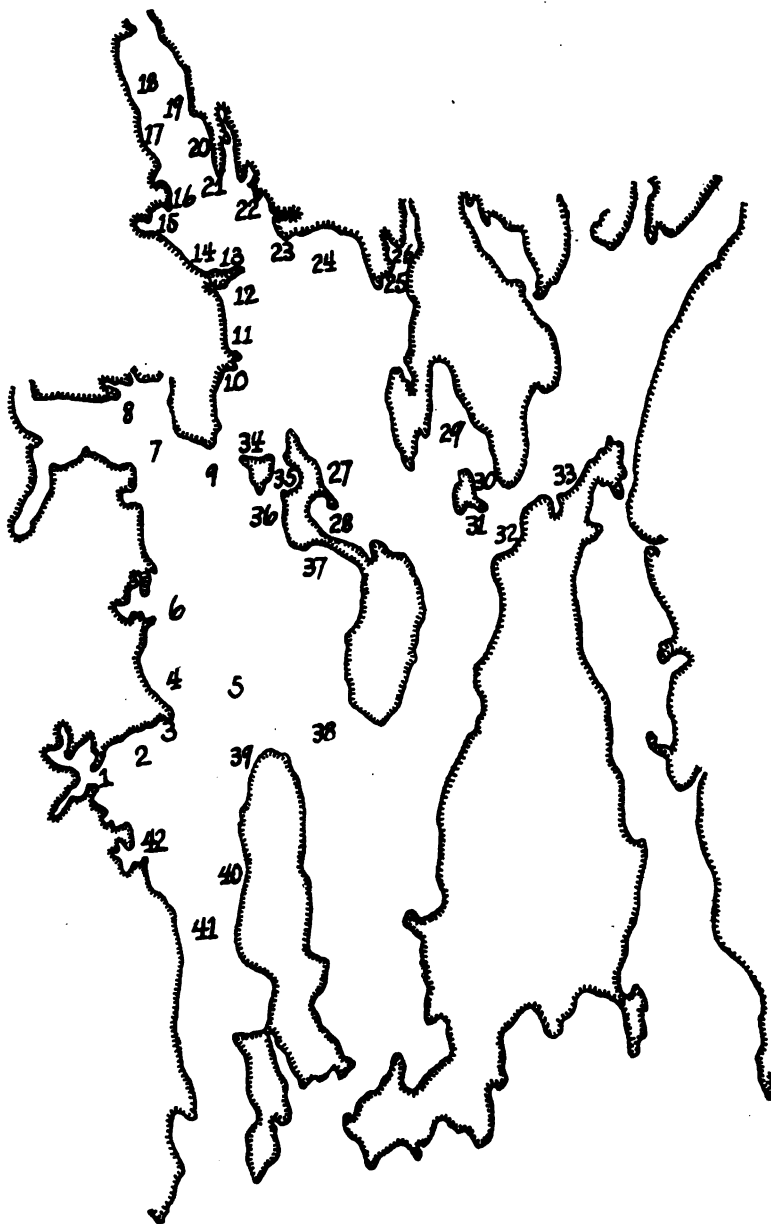
Details of methods and observations follow. To observe the conditions of spawn, samples of oysters were taken by a small dredge from beds at various locations. The eggs and sperm were microscopically examined for form of the egg and motility of the sperm as soon as the samples had been taken in a tub of water to the laboratory. The condition of the eggs in samples taken up to July 26 was, with the exception of one sample from Rocky Point on July 12, comparatively good, with few poorly formed ones. Samples taken later showed an increasing proportion of eggs with disrupted membranes or broken nuclei. Active motility of sperm was observed in every sample. The beds from which oysters were taken for these examinations are located on the accompanying map by the following numbers, 2, 6, 11, 34, and 41. They were regarded as representative of the oyster growing bottoms of the middle and southern portions of the bay. In the table below the relative amount of spawn is represented on a scale of 4. Ten or more individuals were examined in each sample. Those appearing to be full of spawn were graded 4, those nearly full 3, etc. The average for the sample thus stands as a rough estimate of the comparative amount of spawn. A decided decrease occurred about July 27. It might have been expected because of the hot weather which had prevailed

during the week beginning July 21. Samples taken from the same locality, but from different beds, did not show loss of spawn at the same time. The observations point to the general conclusion that oysters in Narragansett Bay produced an abundance of spawn, and while many emitted it during the last week in July there was considerable variation in this respect. No certain relationship between locality and the time of the disappearance of spawn could be traced in these samples.

TABLE OF THE RESULTS OF THE EXAMINATION OF OYSTERS FOR SPAWN.

Date, 1918.	Location.	Number on Map.	Comparative Average of Amount of Spawn. Very full=4.
July 8	Patience Island	34	3.2
July 8	Rocky Point	11	2.9
July 8	Allen's Harbor	6	3.6
July 9	Plum Beach	41	3.0
July 9	Wickford Beacon	2	3.2
July 11	Allen's Harbor	6	2.9
July 11	Wickford Beacon	2	3.0
July 12	Patience Island	34	3.1
July 12	Rocky Point	11	2.0
July 15	Plum Beach	41	2.5
July 15	Wickford Beacon	2	3.2
July 20	Wickford Beacon	2	2.4
July 23	Wickford Beacon	2	3.5
July 26	Patience Island	34	2.5
July 27	Plum Beach	41	1.4
July 27	Wickford Beacon	2	2.6
Aug. 1	Patience Island	34	0.6
Aug. 1	Allen's Harbor	6	0.8
Aug. 1	Wickford Beacon	2	1.1
Aug. 9	Wickford Beacon	2	0.4

An effort was made to test the vitality of the eggs and spawn observed in the various oyster samples. The method was to artificially fertilize *in vitro* using technique found to be most favorable by Nelson. The time elapsing between fertilization and good motility was noted, also the proportion of eggs attaining motility and the number of days which elapsed before all or practically all of the embryos died. To make observations sufficiently accurate to be of



OUTLINE MAP OF NARRAGANSETT BAY.

Showing Locations at Which Samples of Oysters, Water and Shells were taken. The Numbers Indicating the Locations are Referred to in the Tables and Text.

value, however, consumed too much time to permit of other work, so that the attempt was abandoned. Of sixteen experiments, mostly on eggs of one female for each experiment, but fertilized by mixed sperm, all attained the beginning of motility in $3\frac{1}{2}$ or 4 hours. Abundant motility was observed in from 4 to 5 hours. In no experiment did any embryos survive after the fourth day and nearly all died before the end of the third day. Two experiments were tried to see if paraffine lining of glass would prolong the life of the oyster embryos *in vitro*. No difference between them and the controls in non-paraffined glass could be observed. The observations of Nelson, Brooks and others on the poor resistance of oyster embryos to conditions of artificial fertilization are confirmed.

The occurrence and distribution of oyster fry in various parts of the bay were observed in water samples taken between July 20 and August 24. Surface samples were taken with a bucket and filtered through the finest mesh silk bolting cloth, which retained the embryos of very small size. Deeper samples were obtained with a hose and hand pump and were similarly filtered. From 15 to 20 gallons were filtered for each sample. As the numbers of fry when present did not greatly vary in the different samples and were always few, actual counts were not made. In the following table, which records the observations the locations of sampling stations are given by numbers which refer to the accompanying map. No fry were found prior to August 3. This observation is in agreement with the small size of the "sets" observed during September in the main portions of the bay. In the extreme upper part of the bay, where a "set" occurred earlier, as described below, water samples were not taken.

TABLE OF WATER SAMPLES TAKEN FOR FINDING OYSTER FRY.

Date, 1918.	Location Num- ber on Map.	Method of Sampling.	Condition of Tide.	Oyster Fry.
July 20.....	2	Surface.	Rising.	None.
" 24.....	2	Deeper.	Falling.	"
" 24.....	4	"	"	"
" 26.....	2	"	Low.	"
" 26.....	36	Surface.	Rising.	"
" 26.....	34	"	"	"
" 26.....	34	Deeper.	"	"
" 27.....	41	Surface.	Low.	"
" 27.....	41	Deeper.	"	"
" 27.....	2	Surface.	Rising.	"
Aug. 1.....	34	"	"	"
" 1.....	34	Deeper.	"	"
" 1.....	6	"	"	"
" 1.....	6	Surface.	"	"
" 3.....	41	"	High.	"
" 3.....	41	Deeper.	"	Present.
" 6.....	38	Surface.	Falling.	"
" 6.....	38	Deeper.	"	"
" 6.....	37	Surface.	"	"
" 6.....	37	Deeper.	"	"
" 6.....	4	Surface.	Low.	"
" 6.....	4	Deeper.	"	"
" 8.....	11	"	Falling.	None.
" 8.....	10	"	"	"
" 8.....	9	"	"	"
" 9.....	41	"	"	Present.
" 9.....	40	"	"	"
" 9.....	39	"	"	"
" 9.....	2	"	"	"
" 12.....	6	"	Rising.	"
" 12.....	37	"	High.	"
" 12.....	2	"	Falling.	"
" 13.....	41	"	Rising.	None.
" 13.....	40	"	"	"

TABLE OF WATER SAMPLES TAKEN FOR FINDING OYSTER FRY—Concluded.

Date, 1918.	Location Num- ber on Map.	Method of Sampling.	Condition of Tide.	Oyster Fry.
Aug. 13.....	39	"	"	"
" 14.....	8	"	"	"
" 14.....	7	"	"	Present.
" 14.....	6	"	High.	None.
" 15.....	3	"	Rising.	Present.
" 15.....	3	Surface.	"	"
" 15.....	2	Deeper.	"	"
" 15.....	1	"	"	None.
" 17.....	3	"	"	Present.
" 17.....	1	"	"	"
" 17.....	1	Surface.	"	None.
" 19.....	39	Deeper.	Low.	"
" 19.....	39	Deeper.	"	None.
" 19.....	39	Surface.	"	Present.
" 19.....	38	Deeper.	Rising.	"
" 19.....	5	Surface.	"	"
" 19.....	4	"	"	"
" 20.....	41	"	Falling.	None.
" 20.....	40	"	"	Present.
" 20.....	3	"	Low.	"
" 20.....	2	"	Rising.	"
" 24.....	42	"	Falling.	"
" 24.....	1	"	"	None.

The findings of oyster "sets" on shells dredged from various locations during September are shown in the following table. Comparison with the map will show that "sets," valuable in number and age, were found only north of Conimicut Point at number 12 on the map. Most of the beds in this region suitable for "spat" catching had at least some "set." All observations in the main portions of the bay show the conspicuous failure of oyster propagation. Observations in Wickford Harbor are not tabulated. They are described in connection with propagation experiments. A "set" reported at the Narrow River was not investigated.

TABLE SHOWING THE "SET" OF OYSTERS AT VARIOUS LOCATIONS.

Date, 1918.	Location Number on Map.	Total Number Shells Examined.	Number Shells Having Spat.	Total Number Spat Found.	Remarks.
Sept. 5	37	75	39	132	All less than 5 mm. diam.
" 5	36	20	1	1	
" 5	35	42	1	1	
" 5	34	62	5	5	
" 5	9	37	7	8	
" 5	8	47	0	0	Practically no "set." All less than 5 mm. diam.
" 5	6	64	2	2	
" 5	4	60	1	1	
" 10	32	42	0	0	
" 10	33	37	12	31	
" 10	31	53	7	12	Very light "set." All less than 5 mm. diam.
" 10	30	64	16	28	
" 10	29	46	23	48	
" 10	27	83	31	87	
" 10	28	49	8	15	
" 14	41	84	7	9	
" 14	40	82	6	10	

TABLE SHOWING THE "Set" OF OYSTERS AT VARIOUS LOCATIONS—Concluded.

Date, 1918.	Location Number on Map.	Total Number Shells Examined.	Number Shells Having Spat.	Total Number Spat Found.
Sept. 14.....	2	45	7	13
" 23.....	17	56	8	11 (a)
" ".....	18	45	45	* (b)
" ".....	19	59	31	66 (c)
" ".....	20	67	48	134 (c)
" ".....	21	46	43	* (d)
" ".....	22	62	2	2 (d)
" ".....	23	42	2	3 (e)
" ".....	24	62	1	1 (e)
" ".....	25	63	0	0 (e)
" ".....	26	43	0	0 (e)
" ".....	12	62	3	4 (f)
" ".....	13	53	50	* (f)
" ".....	14	37	24	76 (g)
" ".....	15	55	37	66 (g)
" ".....	16	33	14	34 (g)

* Too many to count.

(a) Muddy ground, poor for spat collection.

(b) Good "set." Many of large size.

(c) Light "set," but many of large size.

(d) Good "set." Many of large size.

(e) Practically no "set." All very small.

(f) Good "set." Average 20 mm. diam.

(g) Light "set." No large ones. Mostly less than 20mm. diam.

In the hope that aeration and movement of the water together with its frequent renewal would facilitate an artificial propagation of oysters, a modification of the method used by the Rhode Island Commission of Inland Fisheries for propagation of lobsters at Wickford was tried. Large hatching boxes, made of matched boards, 10 feet square and $4\frac{1}{2}$ feet deep, were provided with two sand filters, 2 feet square, in the floors. There were no openings in the sides. The interior was entirely painted with melted paraffin. Two such boxes were prepared. They were submerged to a depth of four feet while water slowly filtered in and were held in position by fastening them to the framework of the main raft of the floating hatchery. Water was continuously poured in from above

by a chain of paraffin coated metal buckets belted to a pulley moved by the main shafting of the lobster hatching plant. About two gallons of water per minute were delivered to each car. The water entering one car was passed through a sand filter. At the point where the tanks were fastened the water had a mean low tide depth of about 10 feet, with an average tidal rise of 4.1 feet. The temperature and specific gravity of the water in each tank and just outside the tanks were noted frequently. The difference between the temperatures inside and outside the tank never varied by more than 2° F. Specific gravity was the same inside and outside, except as slightly varied by temperature differences. The greatest range of temperatures in the tanks was from 70.7° F. to 79° F. On July 23, oysters dredged from beds near Wickford, about two miles from the hatchery, were brought in as quickly as possible by motor boat. To avoid any unnecessary exposure to adverse condition they were transported in large tubs of sea water protected from the sun. Within a half hour from the time they were dredged sixty oysters selected for large size and good shape were placed in each hatching tank. Ten oysters from the same dredging were opened as a sample and showed plenty of spawn of good appearance. Graded by the scheme explained above they were valued at 3.5 on a scale of 4. On July 27, twenty additional oysters, obtained and selected in the same manner, were put in each tank. These oysters were not as full of spawn as the ones taken on July 23. They were graded at 2.6. On July 28, oysters which had been in the tanks five days were removed. Seven were taken from each tank and opened to estimate the amount of spawn and to examine the eggs and sperm. For fullness of spawn they were graded at 1.9. Nothing of note was observed in microscopic examination. A similar sample on July 30 graded 1.0 and one taken August 7 graded 0.5. These observations indicate a gradual but practically complete disappearance of spawn from the oysters within two weeks after planting in the tanks. Artificial fertilization was carried out with spawn removed from oysters taken out of the tanks on July 28 and July 30. Five hours after fertilization the free swimming embryos were separated from infertile and dead eggs by decantation and 400 c. c. of a suspension containing approximately 5,000,000, embryos, estimated

from Rafter cell counts, were poured into the hatching tanks on each of the dates mentioned. The water in the tanks was examined for oyster fry by straining 15 gallons through bolting cloth and making microscopic examination of the sediment. The examinations were made on July 29, August 4, 5, and 11. On July 29 and August 11, small embryos with measurements correct for oysters but too small, according to Stafford, to be distinguished with certainty from clam embryos were found. On the other two occasions no embryos could be seen. As spat catchers, there were introduced into the hatching cars: (1) unglazed flower pots suspended one foot below the surface of the water and three feet down and resting on the bottom, (2) sun dried, clean oyster shells on the bottom, (3) bunches of dried twigs anchored to the bottom by stones by which they were tied. One of each type of collector was put into each tank at intervals of one week, beginning 20 days after the first planting of oysters. The tank receiving water thru a sand filter was found ten days after starting the experiment to contain noticeably fewer algae than the one receiving unfiltered water. Copepods, however, were about equally abundant in both tanks. Their eggs either escaped the filter or were splashed into the tank. An experiment was made to see if copepods devoured oyster embryos. One cubic centimeter of a suspension of oyster embryos five hours after artificial fertilization was put into each of two watch glasses. One cubic centimeter of sediment rich in various sized copepods freshly strained from seawater was then added to one glass. Observations with binoculars were made several times during the ensuing 24 hours. At no time were copepods seen to molest the embryos and when the experiment was discarded because both embryos and copepods were beginning to stop swimming there were apparently as many embryos in the glass containing the copepods as in the one without. This experiment was repeated with the same result. Under such artificial conditions copepods may not behave as they do in the open but the observation indicates no great avidity on their part for destroying oyster embryos.

On September 14 the hatching experiment was terminated and the tanks prepared for landing. No "set" of oysters was found on any of the spat collectors or on the insides of the tanks. On the

outside, however, a number of well formed oysters, many of them over 20 m. m. in diameter were found. Indeed nearly all the hatching tanks which had been used for lobster propagation between July 15 and September 1, bore more or less oyster set. A board taken from a representative tank had 102 oysters varying in size from 9 to 27 m. m. diameter on an area of 240 square inches. Shells taken from the bottom of Wickford harbor near the hatchery showed no set but some were found near the mouth of a creek entering the harbor. The muddy character of the harbor bottom probably explains the failure of a set there. It is obvious that conditions in the water at Wickford are favorable to oyster propagation and it is very difficult to see how the failure in the hatching tanks was due to anything which happened to the oysters in the embryonic stage. The question at once arises: were the eggs and sperm which the oysters presumably gave off in the tanks and which were used for artificial fertilization deficient in vitality and therefore foredoomed even before development began to die in the embryonic period? The spawn of natural i. e. uncultivated oysters at the mouths of creeks entering Wickford Harbor evidently produced spawn able to come to maturity, yet oysters seemingly in equally good condition, transplanted from beds just outside Wickford Harbor to the hatching tanks produced no spawn of good vitality. Nelson has emphasized the tendency of oysters when transplanted or kept under unnatural conditions to yield a spawn of poor vitality. The extent to which cultivation of oysters in recent years may have disturbed the reproductive functioning seems worthy of investigation. It is notable that the best propagation occurred at the head of Narragansett Bay in a region condemned by the Bureau of Chemistry as ground for cultivation of marketing oysters. Transplantations and operations for removal of star fish are not as extensively practiced there as in the main parts of Narragansett Bay. The condition of eggs found in many specimens of ripe oysters showed deterioration. Broken membranes, disrupted nuclei, and abnormal texture of cytoplasm were frequently observed. Remembering the constant and rather high oxygen utilization of eggs in general one cannot help but wonder what effect a diminished oxygen supply might exert on developing oyster eggs. Oxygen sup-

ply is cut off from a closed oyster. Closures of adults occur after an artificial disturbance and last for more prolonged periods than they would under natural conditions. Might this not be a *modus operandi* by which disturbances of oysters, transplanting, mopping, etc., could produce lowered vitality of oyster eggs? How near to spawning time such a disturbance would have to be in order to produce deteriorating effect it is difficult to conjecture. It is certainly true that eggs are in developmental stages within the gonads during months rather than merely weeks. It is perfectly conceivable that disturbances during the fall and winter might alter the trend of developmental changes. It seems likely, however, that disturbances nearer to spawning time would be more deleterious. There is evidence of its effect on ejection of spawn. Experience of oyster growers shows that a bed mopped for star fish in early summer yields oysters soon afterwards empty of spawn while the oysters on adjacent beds are still well filled with spawn.

Although in general there was less cultivation of oysters in the condemned areas at the mouth of the Providence River than in the main part of the bay, it is nevertheless true that injuries from leasees of oyster beds and from agents of the Rhode Island Shell Fish Commission show that certain beds in the former region were cultivated while certain areas bearing oysters in the main part of the bay had not been disturbed during the past year. The proposition here suggested, then, cannot be looked upon as proven. It is only offered as a suggestion for further investigation rather than as a conclusion. At any rate it appears to the writer that future research concerning the failure of oysters to propagate satisfactorily, should include not only studies of what happens during the free swimming embryonic stages but also a study of conditions affecting development of spawn in the adult and especially development of the eggs. That the quantity and quality of food supply might so effect nutritive conditions as to alter the vitality of oyster eggs is conceivable. It might well be investigated. Possible relations of pollution to this matter are discussed below.

It is obvious to all interested in oyster culture that many factors may be concerned in the limitation of oyster propagation. Temperature changes in the water have been considered both by in-

investigators and practical oystermen. Warming of the water undoubtedly hastens the process. In shallower areas the water warms up earlier in the season. This is doubtless the explanation of the earlier "set" at the Providence River as noted above. The presence of an admixture of fresh water lowering specific gravity is regarded by many as an important factor. It is to be noted that the three localities yielding a "set" as described above were all at or near the mouths of fresh water streams. A third factor is the topography of land and water areas in so far as it affects the movements of tidal and other currents. This may or may not affect the spawning and embryonic life but must affect the "setting." Its influence appears clearly in examination of the map showing location of "sets." The best ones were at numbers 13, 14, 15, 16, 18, 19, 20, and 21. At 17 the bottom is too muddy for successful spat catching. At 22 and 23 the waters are more open to the bay than are the other stations west and north of them because Conimicut Point and sand bars beyond it cut off the areas marked 13 and 14 and produce a considerable tide eddy. The "set", therefore, occurred in a comparatively land locked area furnishing opportunity for warming of the water and confinement of fry. The three factors, temperature, specific gravity, and topography are doubtless of importance. That they are the only and limiting factors is questionable because if so, why should the "set" of oysters in all portions of Narragansett Bay have been formerly very successful as many can testify. It seems as though some factor not so constantly operative as these three and particularly some factor which has appeared more conspicuously in recent years must be of importance.

That pollution is the hitherto unrecognized factor is not clearly shown by these observations. It is in the purest waters that propagation fails while more polluted regions bear the "set." The Providence River receives both domestic and trade wastes emptied into it and its tributaries in large amounts and varied character. The harbor water at Wickford is far from pure, receiving as it does domestic wastes and effluents from muddy and marshy inlets. Spatting in polluted waters and lack of "set" in pure waters has been observed during several seasons by local oystermen. So that

whatever the effect of pollution may be it did not, so far as these observations show, prevent the development of spawn produced north of Conimicut Point early in the summer. In one respect, however, these observations might be taken to indicate an important bearing of pollution upon reproduction. It may cause depletion of adult, spawn-producing oysters in those waters most favorable to the emission of spawn early in the summer. It is reported by persons familiar with the region in former years that natural oysters were once fairly abundant in the Seekonk River and the upper part of the Providence River. That none are to be found there now seems to be the general testimony. That pollution caused their disappearance is, of course, not proven but the possibility should not be overlooked in attacking the problem of oyster propagation. One can readily imagine that if the Seekonk River and the upper part of the Providence River were well populated with good spawn-producing oysters the June spawn production might be enough to yield a satisfactory set over the larger part of the entire Bay.

Another factor which has received much attention and is considered very important in modern oyster culture is condition of the spat catching material especially its freedom from sediment or slime. That this is important to obtain the optimum amount of "set" is doubtless true but that the failure of successful oyster propagation as so frequently and widely reported in recent years is due to that is obviously an untenable view. Abundant planting of clean oyster shells at various periods in the spatting season has repeatedly proved to be of no avail. This is unquestionably true of the Narragansett Bay region. In the observations on "sets" as herein reported it was repeatedly seen that old, crumbling, slimy shells bore spat and in the "sets" observed at the Wickford hatchery, boards and piles by no means clean had collected "set." In this connection it was interesting to note that portions of the hatching plant covered with copper paint served in many cases for the attachment of healthy, good sized spat.

SUMMARY.

1. Oysters failed to propagate during 1918 in the main part of Narragansett Bay.

2. Some more or less satisfactory reproduction took place in certain inlets of the bay.
3. In the main part of the bay oyster fry were not found in the water in significant numbers.
4. Attempts at artificial propagation of oysters failed.
5. That the condition of spawn, especially of the eggs before emission from the adult may be adversely influenced by cultivation or by any circumstance which might interfere with proper exidation or other metabolic changes is suggested. Some evidence that such influence constitutes a limiting factor is given.
6. Temperature, specific gravity and topography as factors affecting propagation are discussed. That they are always limiting factors is questioned.
7. The relation of pollution to oyster propagation is considered. That pollution interfered with satisfactory propagation by destroying free swimming fry is not indicated by these observations. That it may interfere with satisfactory spawn production is suggested.
8. The condition of spat catching material has not, in all probability, been the factor limiting propagation in Narragansett Bay.

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REPORT OF THE CLEANSING OF POLLUTED OYSTERS IN WICKFORD HARBOR.

ALBERT C. HUNTER

In undertaking this investigation in Wickford during the summer of 1918 the object was to determine the feasibility of cleansing the excessively polluted oysters of the Providence River by submerging for known lengths of time in the clean waters of Wickford Harbor. The large volume of sewage and trade waste which is allowed to flow into the Providence River and upper Narragansett Bay has so polluted these waters that the harvesting of oysters is entirely prohibited from some beds while from others oysters may only be harvested during the hibernating season of the oyster. Similar conditions exist in many harbors and bays along the Atlantic Coast, especially in New Haven Harbor and in Jamaica Bay. This condition of affairs has resulted in a great financial loss both to the individual and to the State, as well as in depriving the public at large of valuable growing ground for one of the best of marine foods. In order to find some way of cleansing oysters grown on these polluted grounds so as to make them fit for food at any time of the year, these experiments were carried on at Wickford.

Wickford, R. I., was selected as a location for a field laboratory for several reasons. A large supply of excessively polluted oysters was available in the upper bay while the water in and around Wickford Harbor was known to be clean and reasonably free from pollution. The Commissioners of Inland Fisheries and of Shell Fisheries of Rhode Island allowed the use of the lobster hatchery for a laboratory and offered the services of Capt. Leman Wardsworth during the summer.

A preliminary survey of the waters of Wickford Harbor from the fresh water brook at the Post Road to the beacon at the mouth of the harbor showed the locations which were free from pollution. Three such locations selected for the experiment were along the south side of the channel near the Frank T. Lane oyster house, in the cove between Cornelius Island and Sanga Point and between Sanga Point and the lighthouse.

Through the assistance of Capt. William B. Welden, two lots of oysters were obtained from the Providence River from grounds known to be excessively polluted. These oysters were analyzed and found to score 5,000. They were divided into three lots and each lot placed in a large wooden crate and submerged at the stations named above. At intervals samples were taken from these crates and analyzed. Results of this experiment are given in Table I.

TABLE I.

Sam- ple.	Station.	Tide.	Tempera- ture.	Length of Time.	Score.	Total Count.
C	Conimicut.	.....	.....	.....	5,000	10,000
D	Nayatt.	.....	.....	.....	5,000	25,000
CI	9	Low.	73° F.	6 hrs.	5	*
CA	16	Low.	75° F.	6 hrs.	23	*
DI	6	Low.	75° F.	6 hrs.	410	*
C2	9	Half flood.	75° F.	24 hrs.	230	3,500
Ch	16	Half flood.	75° F.	24 hrs.	410	3,200
D2	6	Half flood.	75° F.	24 hrs.	230	3,000
C3	9	Half ebb.	70° F.	30 hrs.	230	940
Cc	16	Half ebb.	70° F.	30 hrs.	320	1,100
D3	6	Half ebb.	70° F.	30 hrs.	500	1,620
C4	9	4 hrs. ebb.	76° F.	78 hrs.	140	2,000
Cd	16	4 hrs. ebb.	76° F.	78 hrs.	230	870
D4	6	4 hrs. ebb.	76° F.	78 hrs.	50	320
C5	9	4 hrs. flood.	75° F.	98 hrs.	140	1,600
Ce	16	4 hrs. flood.	75° F.	98 hrs.	140	1,000
D5	6	4 hrs. flood.	75° F.	98 hrs.	50	300
C6	9	Half flood.	75° F.	120 hrs.	14	1,000
Cf	16	Half flood.	75° F.	120 hrs.	41	320
D6	6	Half flood.	75° F.	120 hrs.	32	350

*Spreaders on plates.

While this experiment was going on oysters were obtained from the Beacon Oyster Co. and kept suspended beneath the wharf of that company for five days. The water under this wharf is not clean and at the end of five days the oysters were sufficiently polluted for the experiment. Samples of these oysters were found to score

2,300 and 5,000. Only two crates were submerged in this experiment, the location on the south side of the channel near the oyster house being abandoned. Results are given in Table II.

TABLE II.

Sample.	Station.	Tide.	Temperature.	Length of Time.	Score.	Total Count.
E	Beneath wharf.	Half flood.	75° F.	5 days.	2,300	2,000
F	Beneath wharf.	Half flood.	75° F.	7 days.	5,000	5,700
EI	16	Low.	74° F.	24 hrs.	140	1,170
E2	16	Low.	75° F.	48 hrs.	140	*
E3	16	High.	75° F.	54 hrs.	320	*
E4	16	Low.	70° F.	72 hrs.	320	*
E5	16	Low.	70° F.	120 hrs.	320	*
F1	9	Low.	70° F.	120 hrs.	140	*
E6	16	Half ebb.	72° F.	114 hrs.	3	*
F2	9	Half ebb.	72° F.	144 hrs.	5	*

*Spreaders on plates.

In the third experiment oysters from beneath the wharf and from the Providence River were used and scored 4,100 and 2,300. Results of this experiment are given in Table III.

TABLE III.

Sample.	Station.	Tide.	Temperature.	Length of Time.	Score.	Total Count.
G	Lobster cars.	.....	.....	.....	4,100	8,200
H	Beneath wharf.	.....	.....	.....	2,300	5,000
G1	9	2 hrs. ebb.	76° F.	24 hrs.	410	8,000
H1	16	2 hrs. ebb.	76° F.	24 hrs.	140	4,500
G2	9	1 hr. ebb.	71° F.	48 hrs.	140	6,000
H2	16	1 hr. ebb.	71° F.	48 hrs.	140	4,000
G3	9	High.	72° F.	72 hrs.	50	1,500
H3	16	High.	72° F.	72 hrs.	50	1,000
G4	9	5 hrs. flood.	70° F.	96 hrs.	14	350
H4	16	5 hrs. flood.	70° F.	96 hrs.	23	420

From these experiments it is concluded that it is necessary to leave oysters, as excessively polluted as those from the Providence River, in clean water from 96 to 144 hours before they will score below 50. Oysters, which are not so excessively polluted originally, will, no doubt, cleanse themselves in less time. No hard and fast rule can be laid down at this time, but further experiments along this line may show the length of time necessary to cleanse oysters of varying degrees of pollution by transplanting them into clean seawater or at least to clean water of the same density as that in which they are grown. If the cost of such procedure is not prohibitive, this may offer a solution of the problem of cleansing polluted oysters.

Considerable work is being done along the line of purifying oysters by means of calcium hypochlorite and ultra violet light but such experiments have not been, on the whole, successful. If the excessively polluted oyster will cleanse itself in a reasonable length of time on being transferred to pure water, as the experiments described here indicate, then the polluted oyster ground of upper Narragansett Bay may well be utilized during the whole oyster season with profit both to the individual and to the State.

QUAHAUGS

Again we call your attention to the fact that we believe that quahaugs may be as profitably cultivated as oysters, in fact, quahaug cultivation has some advantages over oyster cultivation, as there are much fewer enemies of the quahaugs than of the oyster. The only objections of which we have heard in regard to quahaug cultivation, are that quahaugs are apt to settle in soft ground, and it is pretty difficult to obtain them. But, notwithstanding this fact, we believe that it can be successfully conducted.

To illustrate, what may be accomplished in quahaug culture, will say, that on May 1, 1918, we had 242 bushels of small quahaugs taken from a piece of ground, that we had under observation, at Sand Wharf, in Cowesett Bay and transplanted them on a piece of ground at Buttonwoods, which was closed, to the use of the public, in order that they might not be disturbed and be given an opportunity to grow. We are quite sure that this experiment has been

successful. Our deputies have brought samples of the quahaugs to the office, which have shown a most remarkable growth. It is conservatively estimated that the quahaugs planted would now make at least 1,000 bushels, or about four-fold. While this might seem to be unreasonable, it is a fact. In Massachusetts a series of experiments were conducted by the Fisheries Commission, which demonstrated that quahaugs certainly would add four-fold, and under favorable conditions a much greater number might be obtained.

We are contemplating conducting a more extended series of experiments on quahaug culture during the season of 1919.

The estimated number of quahaugs which were taken from the public ground of Rhode Island during 1918, was 25,000 bushels, valued at about \$4.00 per bushel, making a total value of \$100,000.

CLAMS

Soft-shelled clams, so-called, are one of the specie of shellfish which have no protection under the laws of Rhode Island, excepting in those places where we have closed to the use of the public, in order to demonstrate the fact that clams may be grown with little effort.

We see no reasons why clams should not be as successfully cultivated in Rhode Island as they have been in Massachusetts and Maine. We are informed that clam cultivation in Maine has been successfully conducted, although the areas under cultivation are considerably restricted, as the law of Maine allows only one-quarter of the available ground to be utilized for private cultivation. There was considerable opposition to the leasing of clam flats in Maine by the fishermen, but it was thought that if one-quarter of the available acreage was leased, the clams grown on this one-quarter would propagate and there would be as many or more grown on the other three-quarters.

At the time of the passage of the act, all of the clam-men were opposed to this proposition, but the clam-men of Maine have found that the clams produced on the remaining three-quarters of ground equals what was formerly produced on all the public ground.

That being the fact, we see no reasons why Rhode Island might not profit by leasing one-quarter of the available clam flats without any material injury to the fishermen, and to the material benefit of the citizens of the State. There is no doubt whatever but what clams grown upon private ground can be produced and sold at reasonable prices.

The estimated number of clams taken from public ground during 1918, was 40,000 bushels, valued at about \$1.75 per bushel or a total of \$70,000.

SCOLLOPS

The scallop season during the past year has not materially changed from the previous season. The area for scallop culture is considerably restricted although it was more extensive last year, than previously, although the scallops were not as thick in some sections as formerly, but we are looking forward to an increased catch in the near future.

The estimated catch of scallops for 1918 was about 3500 gallons, at an average price of \$4.00 per gallon, making a total of \$14,000. We would say that in regard to the price of \$4.00 per gallon, that is probably in excess of what the fishermen obtain for their scallops, but that is the wholesale price of scallops.

MUSSELS

Last year, we made an extended report to your Honorable Body relative to mussel beds in Rhode Island, which was accompanied by a report from Dr. Irving W. Field of the U. S. Bureau of Fisheries, who had studied the problems during the season of 1917.

We again call your attention to the fact that there are extensive mussel beds in Rhode Island that might be utilized for the growing of mussels, and we particularly desire to call your attention to the fact that the U. S. Bureau of Fisheries is conducting a campaign of education, endeavoring to secure a market for mussels. The only use which has ever been made of mussels in Rhode Island has been for fish bait, and there is no law preventing people digging mussels and using them for fish bait, although it would seem to us

that a much better use of mussels might be made. The estimated number of mussels taken from public ground in 1918 was 8,000 bushels valued at about \$4,000.

Quoting from the report of Dr. Field, we wish to particularly call your attention to the fact that "Narragansett Bay presents one of the richest areas for cultivation on the North Atlantic Coast. Protected from the entrance of heavy seas, shallow enough to permit cultivation in nearly all of its parts and to allow the water to be warmed quickly by the sun's rays, rich in its content of plankton organism and detritus and with most of the bottom hard, sticky or muddy, it is an ideal region for the cultivation of oysters, clams and mussels. Practically every part of the bay is adapted for the growth of one or more kinds of these shellfish, cultivation of which will yield far greater food returns with less expense of worry, time and energy than can be obtained from any of the agricultural products." AS A SOURCE OF FOOD PRODUCTION AND WEALTH, THEREFORE, THE BAY IS WORTH FAR MORE TO THE STATE OF RHODE ISLAND THAN AN EQUAL AREA OF AGRICULTURAL TERRITORY.

SUMMARY AND RECOMMENDATIONS

1. Narragansett Bay is an exceptionally rich territory for the production of shellfish.
2. The area of natural mussel beds alone was found to aggregate 1,100 acres with an estimated yield of 1,452,000 bushels.
3. More than 2,000 acres of mussel beds have been destroyed to make room for oysters, but hardly more than one-half of these grounds have actually been utilized.
4. In view of the fact that the food value of sea mussels is equal to that of any other shellfish, it is recommended that steps be taken to prevent, hereafter, the unnecessary and wasteful destruction of the mussel beds in Narragansett Bay, and that wide publicity be given to the qualities of the mussel as a food product by means of special articles in newspapers and magazines, lectures and demonstrations in churches, schools and Y. M. C. A. buildings and by co-operating with proprietors of markets, hotels and restaurants, in

bringing them prominently before the public. It is believed that such a campaign of education if properly conducted will result in building up a new and profitable industry in the State of Rhode Island and add considerably to the food resources of the nation."

We particularly desire to call your attention to this quotation as being made by one of the foremost shellfish experts in the country.

STARFISH

We have repeatedly called your attention to the destructiveness of the starfish and we again feel compelled to call your attention to the fact that starfish are a menace to the oyster fisheries of Rhode Island, particularly to the lower bay. With the upper bay being destroyed by pollution and the lower bay being over-run by starfish, the oystermen are up against a pretty severe problem and they have repeatedly called your attention to this condition and we have repeatedly brought this condition to your attention in our report, and have gone before you with recommendations for funds to help exterminate the starfish.

The oystermen take care of their own grounds without any assistance from the State, in fact, do not ask for or expect to receive any assistance from the State in caring for their own areas, but they do feel that the State is not using them fairly when it will not attempt to remove the stars from the public areas.

Starfish not only destroy oysters, but they destroy enormous quantities of young clams. This can be and has been demonstrated a number of times; because of the fact that the young stars are formed and go into the seaweed for protection from their enemies, from two or three weeks before the young clam, so that when the clam arrives and attempts to protect itself by the same means, it finds the young star there ready to destroy them in large quantities. It has been demonstrated that one star, in six days, devours over fifty clams. Therefore it is almost impossible to figure or even estimate the number of clams that are being destroyed by the young stars every season. We believe that stars ought to be removed from the waters of the State, and they ought to be used as fertilizer. We have taken this matter under consideration and have secured con-

siderable data relative to the same, and we feel that there could be a fertilizing plant established under the supervision of the Board of Agriculture, and these stars could be utilized to exceedingly good advantage, not only to the aquaculturist, but to the agriculturist.

POLLUTION

There have been several complaints made to the Board relative to the pollution of Narragansett Bay. One of them was made by the Edgewood Yacht Club on October 3, 1918, and another was made by the Rhode Island Yacht Club on October 15th, 1918, also a complaint was made on October 26, 1918, by Henry B. Barstow of East Providence and John P. Donahue of Providence relative to the discharge of acids from the Nonnabo Chemical Co. These complaints have been investigated and there is no doubt whatever but what the complaints have just cause. But we have been unable to give relief as it is almost impossible for us to secure sufficient evidence to bring suits under any existing laws, although the Attorney General has indictments against four companies under the Common Law, now pending in the Superior Court. We certainly trust that these indictments will be successful.

NEW GROUND

During 1918, we leased 86.6 acres at \$10 per acre, 1.6 acres at \$5 per acre and 12.5 acres at \$1 per acre, making a total of 100.7 acres leased.

GROUND CANCELLED

We regret very much that we are compelled to again call your attention to the fact that many acres of oyster ground were cancelled during the past season. We are compelled to report that during the year 1918, there were cancelled 454.1 acres at \$10, and 1105.6 acres at \$5, making a total of 1559.7 acres cancelled.

Perhaps the best way to call your attention to the decrease of the oyster industry in Rhode Island is to make a comparison of the conditions on December 31, 1912, and on December 31, 1918, a period of six years. On December 31, 1912, the number of acres of

ground leased as shown by the records in the Office of the Commissioners of Shell Fisheries was 5884 acres at \$10 per acre and 15,352.5 acres at \$5 per acre, making a total of 21,236.5 acres. The rentals of this ground amounted to \$135,602.50.

On December 31, 1918, the number of acres leased as shown by the records in the Office of the Commissioners of Shell Fisheries were 3997.4 acres at \$10 per acre, 5000.9 acres at \$5 per acre and 252.5 acres at \$1 per acre, making a total of 9250.8 acres. The rentals of this ground amounted to \$65,226.95.

This shows a net decrease in acreage on the \$10 ground of 1886.6 acres or 32%. On the \$5 ground it shows a decrease in acreage of 10,351.6 acres or 67.42%. It also shows a decrease on the total acreage in Rhode Island of 11,985.7 acres or 56.43%. The decrease in rentals as shown by the above figures is \$70,375.55 or 56.32%.

LEASED GROUND

The number of acres of ground that are under lease, as recorded in the books of the Commissioners of Shell Fisheries, on December 31, 1918, is as follows: 3,997.4 acres at \$10 per acre, 5000.9 acres at \$5 per acre and 252.5 acres at \$1 per acre, making a total of 9,250.8 acres. Total rental amounts to \$65,226.95.

Financial Statement of the Oyster Industry from January 1, 1918, to December 31, 1918.

RECEIPTS.

Received from rent of oyster ground.....	\$74,999 20
Received from interest	1,070 77
Received from fees (Transfer and Cancellation).....	23 00
Received from fishermen's licenses	576 00
Received from scollop licenses	340 00
	<hr/>
	\$77,008 97

DISBURSEMENTS ALLOWED BY COMMISSIONERS OF SHELL FISHERIES.

Salaries Provided by Law.

Salaries of Commissioners	\$2,500 00
Salary of Clerk	1,800 00
For Clerical Assistance	600 00
	<hr/>
	\$4,900 00
Appropriation allowed for expenses of department.....	\$12,000 00
Salaries of deputies	\$5,249 02
Engineering and surveying	1,516 00
Stenographer	720 00
Sanitary work	983 96
Laboratory Supplies	107 54
Inspection of Oyster houses	500 00
Licensed fishermen's boat numbers	102 30
Advertising cancellations	72 75
Printing	83 45
Traveling expenses of committee	442 58
Postage stamps and office supplies	259 45
1918 Maps	71 66
Toll calls	5 52
Operating and supplies for boat	796 07
Use of wharf shop	27 50
Planting shell fish	358 75
Skiffs	85 19
Witness fees	17 15
Quahaug rakes	15 00
Engraving resolutions	20 00
Filing cabinet	124 20
	<hr/>
	\$11,558 09
Unexpended balance	441 91
	<hr/>
	\$12,000 00

REPORT OF COMMISSIONERS OF SHELL FISHERIES.

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Receipts for the year 1918.....	\$77,008 97
Salaries provided by law	\$4,900 00
Expenses of department	11,558 09
	<hr/> 16,305 23
Net revenue ,	<hr/> \$60,703 74

ALPHABETICAL LIST

*Of names of lessees of oyster ground with the number of acres held by each,
and the amount of rental received by the State for same.*

NAME.	Town.	Acres, \$10.00	Acres, \$5.00	Total Acres.	Amount.
American Oyster Corp.....	Providence	199.3	146.6	345.9	\$2,726 00
Baker, Nicholas	North Kingstown...	12.1	94.3	106.4	592.50
Baker, Joseph W.	North Kingstown...	12.3	6.1	18.4	153.50
Barnes, Edwin G.	Westerly	1.0	.....	1.0	10.00
Barnes, Jeremiah I.	Westerly	1.5	.....	1.5	15.00
Beacon Oyster Co.....	Wickford	132.4	78.6	211.0	1,717.00
Blount, Eddie B.	Warren	29.8	16.4	46.2	380.00
Bowden, John F.	Barrington	1.1	.....	1.1	11.00
Bourne, John E.	Providence	76.1	55.1	131.2	1,036.50
Buckingham, Erastus M.	Warren	67.1	3.9	71.0	690.50
Cape Ann Fish Co.	Providence	27.8	4.4	32.2	300.00
Coggeshall, Josiah	Warren . . . . .	.1	7.9	8.0	40.50
Connolly, Thomas H.	Warren	367.5	149.7	517.2	4,423.50
Cornell, Sidney	Warwick	5.8	.....	5.8	58.00
Cottrell, George F.	Tiverton	85.8	126.9	212.7	1,492.50
Chase, Melvin C.	Bristol	22.0	33.9	55.9	389.50
Clark & Arnold.	Bristol	2.7	.....	2.7	27.00
Coffin, Henry	East Providence.	2.7	.....	2.7	27.00
Daniels, William W.	Barrington	138.9	6.1	145.0	1,419.50
Dodge, David R.	Warwick	31.0	.....	31.0	310.00
Dodge, John W.	Barrington	19.2	.....	19.2	192.00
Dodge, Sarah M.	Warwick	5.7	.....	5.7	57.00
East Providence Oyster Co.	East Providence	32.0	11.4	43.4	377.00
Fearney, John T.	Providence	54.0	128.2	182.2	1,181.00
Field, Waterman E.	Warwick	8.5	.....	8.5	85.00
Fortin, James	East Greenwich.	1.8	10.2	12.0	69.00
Gladding, Theodore O.	Bristol	57.8	90.8	148.6	1,032.00
Goodspeed, Joseph W.	Warren	54.2	13.3	67.5	608.50
Greene, Charles W.	Warren	16.2	24.3	40.5	283.50
Greene, George T.	Warren	19.9	22.3	42.2	310.50
Griffin, Edward W.	South Kingstown... .	2.0	.....	2.0	20.00
Havens, L. & W. D.	Warwick	39.3	37.2	76.5	579.00
Higgins, R. R. Co. (R. I.)	Barrington	182.0	61.6	243.6	2,128.00
Johnson, Henry C. 2nd.	North Kingstown... .	8.6	1.4	10.0	93.00
MacMillan, Murdock	Providence	424.5	1287.8	1712.3	10,684.00
Milliken, John W.	Warwick	8.4	.....	8.4	84.00
Miner, Albert D.	East Greenwich.	3.7	.....	3.7	37.00
Nayatt Point Oyster Co.	Providence	119.3	112.0	231.3	1,753.00

ALPHABETICAL LIST—Concluded.

NAME.	Town.	Acres, \$10.00	Acres, \$5.00	Total Acres.	Amount.
Narragansett Bay Oyster Co.....	Providence	632.9	1201.6	1834.5	12,337.00
Parmelee, Charles W.	Providence	132.2	118.7	250.9	1,915.50
Pettis, Frank C.....	Providence	125.6	105.3	230.9	1,782.50
Rocky Point Oyster Co.....	Providence	202.6	27.4	230.0	2,163.00
R. I. Oyster Farms Co.....	East Providence....	418.1	650.8	1068.9	7,435.00
Rooks, Benjamin J.....	Warwick	12.5	51.7	64.2	383.50
Shepard, Wilhelmina	Bristol	124.1	16.3	140.4	1,322.50
Smith, Fred G.....	North Kingstown...	39.8	.4	40.2	400.00
Thompson, George L.....	Bristol	1.7	2.8	4.5	31.00
Welden, William B.....	Providence .....	.....	96.8	96.8	484.00
Wheeler, Walter E.....	Westerly	25.2	196.5	221.7	1,234.50
White, Mary J.....	Warwick	2.6	.....	2.6	26.00

NAME.	Town.	Acres, \$1.00	Amount.
Cottrell, George F.	Tiverton.....	12.5	\$12.50
Waite, Warren A.	Tiverton.....	90.0	90.00
Dooley, James E.	Providence.....	150.0	150.00

All of which is respectfully submitted.

EDWARD ATCHISON,
MILTON DUCKWORTH,
HENRY K. LITTLEFIELD,
CLINTON D. LEWIS,
SYLVESTER K. M. ROBERTSON,

Commissioners of Shell Fisheries.

DEC 1 1922

